



Publication number: **0 268 237 A2**

EUROPEAN PATENT APPLICATION

(21) Application number: 87116861.3

(51) Int. Cl.: G01N 1/10, G01N 35/00, G01F 11/02

(22) Date of filing: 16.11.87

(30) Priority: 17.11.86 US 931476

(43) Date of publication of application: 25.05.88 Bulletin 88/21

(54) Designated Contracting States:
AT BE CH DE ES FR GB GR IT LI LU NL SE

(71) Applicant: ABBOTT LABORATORIES

Abbott Park Illinois 60064(US)

(72) Inventor: Hayes, Donald J.

2012 Tampicko Drive
Plano Texas 75075(US)

Inventor: Wallace, David B.
9929 Wood Forest
Dallas Texas 75243(US)

Inventor: Verlee, Donald J.

563 Drake Street
Libertyville Illinois 60048(US)

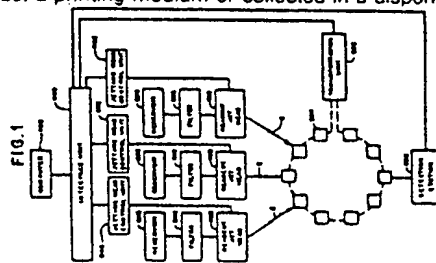
Inventor: Houseman, Kenneth R.
1520 S. Main Street
Racine Wisconsin 53403(US)

(74) Representative: Modiano, Guido et al

MODIANO, JOSIF, PISANTY & STAUB
Modiano & Associati Via Meravigli, 16
I-20123 Milan(IT)

(54) Apparatus and process for reagent fluid dispensing and printing.

(57) A system for printing and dispensing chemical reagents in precisely controlled volumes onto a medium at a precisely controlled location. A jetting tube, comprising an orifice at one end and a fluid receiving aperture at the other end, is concentrically mounted within a cylindrical piezo-electric transducer. The fluid receiving aperture is connected to a reservoir containing a selected reagent by means of a filter. The reservoir is pressurized by a regulated air supply. An electrical signal of short duration is applied to the transducer. The pulse causes the transducer and the volume defined by the jetting tube to expand, thereby drawing in a small quantity of reagent fluid. The cessation of the pulse causes the transducer and the volume of the jetting tube to de-expand, thereby causing at least a substantially uniformly sized droplet of reagent fluid to be propelled through the orifice. The droplet may be directed to impact a printing medium or collected in a dispensing receptacle.



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M O N I T O R I N G

APPARATUS AND PROCESS FOR REAGENT FLUID DISPENSING AND PRINTING

BACKGROUND OF THE INVENTION

5 The present invention relates to an apparatus and process for dispensing and printing reagent fluids, wherein a transducer is used to propel small quantities of the fluid towards a positioned target.

Diagnostic assays often require systems for metering, dispensing and printing reagent fluids. In the case of metering and dispensing, such systems comprise both manual and automatic means. For purposes of practicality, the present background discussion will focus on the methods of metering and dispensing 100 micro-liter volumes or less.

10 The manual systems of metering and dispensing include the glass capillary pipet; the micro-pipet; the precision syringe; and weighing instruments. The glass capillary pipet is formed from a precision bore glass capillary tube. The pipet typically comprises a fire blown bulb and a tubular portion fire drawn to a fine point. Fluid is precisely metered by aspirating liquid through the tube into the bulb to a predetermined level indicated by an etched mark. The fluid may then be dispensed by blowing air through the tube.

15 The micro-pipet typically comprises a cylinder and a spring loaded piston. The travel of the piston is precisely determined by a threaded stop. The distance the piston travels within the cylinder and the diameter of the cylinder define a precise volume. The fluid is aspirated into and dispensed from the micro-pipet in precise quantities by movement of the piston within the cylinder.

20 The precision syringe generally comprises a precisely manufactured plunger and cylinder with accurately positioned metering marks. The fluid is introduced into and dispensed from the syringe by movement of the plunger between the marks.

Weighing techniques for dispensing fluids often simply involve weighing a quantity of fluid. The density of the fluid may then be used to determine the fluid volume.

25 Exemplary automatic metering and dispensing systems include the precision syringe pump; the peristaltic pump; and the high performance liquid chromatography (HPLC) metering valve. The precision syringe pump generally comprises a precision ground piston located within a precision bore cylinder. The piston is moved within the cylinder in precise increments by a stepping motor.

30 The peristaltic pump comprises an elastomeric tube which is sequentially pinched by a series of rollers. Often the tube is placed inside a semi-circular channel and the rollers mounted on the outer edge of a disc driven by a stepping motor. The movement of the rollers against the tubing produces peristaltic movement of the fluid.

The HPLC metering valve comprises a defined length of precision inner diameter tubing. The fluid is introduced into the defined volume of the tubing with the valve in a first position and then dispensed from the tubing when the valve is placed in a second position.

35 All of the above metering and dispensing systems have the disadvantage that the volumes dispensed are relatively large. Furthermore, these systems are also relatively slow, inefficient and comprise precision fitted components which are particularly susceptible to wear.

40 The printing of reagent fluids is frequently required in the manufacture of chemical assay test strips. Selected reagents are printed in a desired configuration on strips of filter paper. The strips may then be used as a disposable diagnostic tool to determine the presence or absence of a variety of chemical components.

45 Generally, to perform a chemical assay with a test strip, the strip is exposed to a fluid or a series of fluids to be tested, such as blood, serum or urine. In some instances, the strip is rinsed and processed with additional reagents prior to being interpreted. The precise interpretation depends on the type of chemical reactions involved, but it may be as simple as visually inspecting the test strip for a particular color change.

The manufacture of test strips generally involves either a manufacturing process or a blotting process. The blotting process is the simplest manufacturing method and permits most reagents to be applied without modification. A disadvantage of this process is that it is difficult to blot the fluids onto the test strip with precision.

50 The printing process will often involve any of three well known methods: silk screening; gravure; and transfer printing. The silk screening of reagents generally involves producing a screen by photographic methods in the desired configuration for each reagent to be printed. The screen is exposed under light to a preselected pattern and then developed. The areas of the screen which are not exposed to light, when developed, become porous. However, the areas of the screen which have been exposed to light remain relatively nonporous. The screen is then secured in a frame and the test strip placed below. The desired

reagent fluid, specially prepared to have a high viscosity, is spread over the top side of the screen. The reagent passes through the porous areas of the screen and onto the test strip. The test strip is then subjected to a drying process, specific to each reagent. Once the test strip is dry, it may be printed again using a different screen, pattern and reagent.

5 The gravure method of printing reagents comprises coating a metal surface with a light sensitive polymer. The polymer is exposed to light in the desired predetermined pattern. When developed, the polymer creates hydrophilic and hydrophobic regions. The reagent is specially prepared such that when applied to the metal it will adhere only to the hydrophilic regions. After the specially prepared reagent is applied, the test strip is pressed against the metal and the reagent is transferred from the metal to the test strip.

10 The transfer printing method comprises transferring the reagents from a die to the test strip in the desired pattern. The die is made with the appropriate pattern on its surface and then coated with the desired, specially prepared reagent. A rubber stamp mechanism is pressed against the die to transfer the reagent in the desired pattern from the die to the rubber stamp. The rubber stamp is then pressed against the test strip to transfer the reagent, in the same pattern, to the test strip.

15 Each of the above-mentioned reagent printing techniques has significant disadvantages. The most common disadvantage is the requirement that the reagents must be specially prepared. Additionally, if a variety of reagents are to be printed onto a single test strip, the strip must be carefully aligned prior to each printing. This alignment procedure increases the cost and decreases the throughput of the printing process. Moreover, a special die or screen must be produced for each pattern to be printed. A further disadvantage arises in that the above printing methods are unable to place reproducible minute quantities of reagent on the test strip.

It is an object of the present invention to provide a printing and dispensing method and apparatus which avoids these disadvantages.

SUMMARY OF THE PRESENT INVENTION

25 The present invention is directed to a reagent dispensing and printing apparatus and method, wherein the apparatus comprises a transducer operative to eject a substantially uniform quantity of reagent in a precise predetermined direction.

According to one preferred embodiment of the present invention used in dispensing reagent fluids, a jetting tube is concentrically located with a piezoelectric transducer. The jetting tube comprises an orifice at one end and a reagent receiving aperture at the other end. The receiving end of the jetting tube is connected to a filter which is in turn connected to a reservoir containing a selected reagent. A jetting control unit supplies an electrical pulse of short duration to the transducer in response to a command issued by a computer. The electrical pulse causes the volume defined by the jetting tube to expand by an amount sufficient to intake a small quantity of reagent fluid from the reservoir. At the end of the pulse duration, the transducer de-expands propelling a small quantity of the reagent fluid through the orifice and into a fluid receptacle. If desired, additional droplets may be deposited in the receptacle or the receptacle aligned with an additional jetting tube for receiving an additional reagent fluid.

35 An additional preferred embodiment of the present invention may be used for printing reagent fluids onto a print medium. In this embodiment, the jetting tube is aligned with the printing medium such that the propelled droplet impacts a precise position on the medium. The jetting tube or print medium may then be repositioned and another droplet expelled from the jetting tube. The process may be repeated until a desired configuration of the reagent fluid is printed on the medium.

40 One advantage of the present invention is that precise minute quantities of reagent fluid may be dispensed or printed in a reproducible manner. Additionally, the method and apparatus may be used to emit droplets of fluids having a wide range of reagent fluid viscosities and surface tensions. The reagents do not in general have to be specially adapted for use with the present invention.

50 The invention itself, together with further objects and attendant advantages, will best be understood by reference to the following detailed description, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a schematic representation of a first preferred embodiment of the present invention showing the use of multiple jetting heads to meter and dispense reagent fluid.

FIGURE 2a is a perspective view of a first preferred embodiment of the jetting head of the present invention.

FIGURE 2b is a cut-away perspective view of the preferred embodiment of Fig. 2a taken along lines 2b-2b with the contact pins removed.

FIGURE 2c is a sectional representation of the preferred embodiment of Fig. 2a taken along lines 2c-2c.

FIGURE 2d is a sectional representation of the preferred embodiment of Fig. 2c taken along lines 2d-2d.

FIGURE 2e is a sectional representation of the jetting tube and transducer of the preferred embodiment of Fig. 2b taken along lines 2e-2e.

FIGURE 3 is a schematic representation of a second preferred embodiment operating in the drop on demand mode as a reagent printing system.

FIGURE 4 is a schematic representation of a third preferred embodiment operating in the continuous mode as a reagent printing system.

FIGURE 5a is a schematic representation of a portion of the jetting head control unit showing the LED strobe circuit.

FIGURE 5b is a schematic representation of a portion of the jetting head control unit showing the high voltage power supply circuit.

FIGURE 5c is a schematic representation of a portion of the jetting head control unit showing the print control circuit.

FIGURE 5d is a schematic representation of a portion of the jetting head control unit showing a portion of the print pulse generator.

FIGURE 5e is a schematic representation of a portion of the jetting head control unit showing an additional portion of the pulse generator.

FIGURE 6a is a perspective view of a second preferred embodiment of the jetting head of the present invention.

FIGURE 6b is an exploded view of the preferred embodiment of Fig. 6a.

FIGURE 7 is a sectional representation of a third preferred embodiment of the jetting head of the present invention.

FIGURE 8 is a sectional view of a symmetrical portion of a fourth preferred embodiment of the jetting head of the present invention.

FIGURE 9 is a graph of the drop mass of the emitted droplets as a function of emission frequency for several fluid viscosities.

FIGURE 10 is a graph of the velocity of the emitted droplets as a function of frequency for several fluid viscosities.

FIGURE 11 is a graph of the total weight of fluid emitted as a function of the number of emitted droplets for a given fluid.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

Turning now to the drawings, Fig. 1 shows a schematic representation of a first preferred embodiment of a reagent dispensing system generally represented as reference numeral 30. The dispensing system 30 comprises a plurality of reagent fluid reservoirs 200, a plurality of filters 300, a plurality of reagent jetting heads 400, a plurality of jetting head control units 500, an interface unit 600, a computer 700, transportation unit 902, a plurality of fluid mixing cells 904 and a detection station 906.

The reservoir 200 holds a selected quantity of reagent fluid for dispensing. The reservoir 200 is maintained at atmospheric pressure by suitable means such as an atmospheric vent. The reagent fluid is transferred from the reservoir 200 through the filter 300 to the reagent jetting head 400. The filter 300 is placed between the reservoir 200 and the jetting head 400 to ensure that any particular foreign matter in the reagent fluid is trapped before entering the jetting head 400.

The plurality of jetting heads 400 and the detection station 906 define a processing path. Each jetting head 400, which is described in detail below, ejects uniformly sized droplets 2 of reagent fluid. The droplets 2 are propelled, with controlled velocity and direction, towards a selecting mixing cell 904 positioned along

the processing path by the transportation unit 902. The mixing cells 904 are comprised of non-reactive material and function as minute holding tanks for the dispensed reagent fluid.

The plurality of jetting heads 400, shown in Fig. 1, are positioned sequentially along the processing path. Alternately, some or all of the plurality of jetting heads 400 may be positioned with respect to the transportation unit 902 such that the heads 400 direct the droplets 2 into a selected mixing cell 902 simultaneously.

The jetting heads 400 and the transportation unit 902 are controlled by the computer 700. The computer 700 issues commands to an interface unit 600 which is electrically connected to the transportation unit 902 and to the jetting head control unit 500. The interface unit 600 is of conventional design and is used to control the transfer of information between the computer 700 and the jetting control unit 500. The interface unit 600 is also used to control the transfer of information between the computer 700 and the transportation unit 902.

A first embodiment of the reagent jetting head is shown in Figs. 2a - 2e and generally represented by numeral 400. The jetting head 400 comprises a two piece symmetrical housing 402, 404. The housing 402, 404, when assembled, is adapted to form an orifice aperture 406, an air vent and reagent supply channel 410 and a transducer chamber 403, shown in Fig. 4b. Four screws 408, adapted to respective housing screw apertures 416, hold the housing 402, 404 in an assembled configuration.

The jetting head 400 further comprises a jetting tube 432, a piezo-electric transducer 434 and a reagent fluid supply tube 430. The jetting tube 432 defines a tapered orifice 433 at one end and a fluid receiving aperture 431 at the other end for expelling and receiving fluid, respectively. The piezo-electric transducer 434 is cylindrically shaped and secured concentrically about the mid-region of the jetting tube 432 with epoxy or other suitable means.

The piezo-electric transducer 434, shown in Fig. 2e, defines a first and second end and comprises a section of cylindrically shaped piezo-electric material 435. An inner nickel electrode 437 covers the inner surface of the cylinder 435. The electrode 437 wraps around the first end of the cylinder 435 a sufficient distance to enable electrical connection external to the cylinder 435.

A second nickel electrode 436 covers the majority of the outer surface of the cylinder 435. The second electrode is electrically isolated from the first electrode 437 by an air gap at the face of the second end of the cylinder 435 and by an air gap on the outer surface of the cylinder 435 near the first end. When an electrical pulse is applied to the first and second electrodes 437, 436 a voltage potential is developed radially across the transducer material 435. The voltage potential causes the radial dimensions of the transducer 435 to change, which causes the volume defined by the transducer 434 to also change.

The jetting tube 432 is positioned in the transducer chamber 403 such that the receiving end 431 extends beyond the rearward end of the transducer 434. The receiving end 431 of the jetting tube 432 is inserted into one end of a reagent supply tube 430. The supply tube 430 is sealingly held to the jetting tube 432 by concentric teeth 412 formed by the housing sections 402, 404. The teeth 412 not only seal the supply tube 430 to the jetting tube 432, but, also, seal the supply tube 430 to the housing 402, 404.

The second end of the supply tube 430 passes through the channel 410 and into a reagent reservoir 200. The reservoir 200 contains the reagent fluid to be dispensed by the jetting head 400. As the reagent fluid is dispensed, air is supplied to the reservoir 200 through the channel 410 to prevent the creation of a vacuum in the reservoir 200. The reservoir 200 is releasably attached to the housing 402, 404 and held in place by frictional forces. A reservoir cap 202 is flexibly attached to the reservoir 200 and adapted such that the cap 202 may be used to secure the opening in the reservoir 200 when the reservoir 200 is disengaged from the housing 402, 404.

The position of the jetting tube 432 defines the horizontal plane of the jetting head 400. The jetting tube 432 and the transducer 434 are held in a pre-defined vertical relationship with respect to the housing 402, 404 by means of two upper vertical alignment pins 418 and two lower vertical alignment pins 418. The two upper vertical alignment pins 418 extend horizontally from the housing section 402 into the transducer chamber 403. Similarly, the two lower vertical alignment pins 418 extend horizontally from the housing section 404 into the transducer chamber 403. Each vertical alignment pin 418 is formed integrally with the respective housing sections 402, 404.

The jetting tube 432 and the transducer 434 are held in a predefined horizontal relationship with respect to the housing 402, 404 by means of four horizontal alignment pins 424. Two of the horizontal alignment pins 424 extend horizontally from the housing section 402 approximately midway into the transducer chamber 403. Similarly, two of the horizontal alignment pins 424 extend horizontally from the housing section 404 approximately midway into the transducing chamber 403. Each horizontal alignment pin 424 is formed integrally with the respective housing section 402, 404. The alignment pins 418, 424, sealing teeth 412 and orifice aperture 406 are aligned and adapted to hold the jetting tube 432 and transducer 434 such

that the orifice 433 of the jetting tube 432 extends into the orifice aperture 406.

An electrical transducer activation pulse is supplied to the piezo-electric transducer 434 from the jetting head control unit 500 by means of two contact pins 422. A quantity of fluid will be dispensed from the jetting tube for each applied activation pulse. The activation pulse can be produced by a variety of conventional circuits or commercially available units. Therefore a detailed description of such a circuit will not be provided. However, a circuit for producing a series of activation pulses is provided in the description of the printing embodiment below. Due to the differing constraints involved in dispensing and printing, the circuit in the printing embodiment is not required to produce only a single pulse. However, one skilled in the art could, if desired, modify the circuit to produce a single pulse on demand for use in the dispensing embodiment.

Each contact pin 422 defines an enlarged head 423 which is adapted to contact the respective first and second electrodes 437, 436 located on the outer surface of the transducer 434. Two contact pin holders 414, integral with the housing 402, 404, are positioned to hold the respective contact pins 422 under the pin heads 423 such that each pin head 423 electrically engages the appropriate electrode 437, 436 of the transducer 434. Two contact pin engaging posts 420 extend from the housing 402, 404 opposite the contact pin holders 414 to engage and hold the contact pins 422 against the contact pin holders 414. The ends of the contact pins 422 opposite the pin heads 423 extend through the housing 402, 404 by means of contact pin apertures 421. Since the housing sections 402, 404 are formed symmetrically to one another, the contact pins 422 may be optionally attached above the transducer 434.

In operation, the reservoir 200 containing reagent fluid is fastened to the jetting head 400 such that the fluid supply tube 430 extends into the reagent fluid. The filter 300 may be fitted to the free end of the supply tube 430 or positioned inside the reservoir 200. Air is supplied through the channel 410 around the supply tube 430 to prevent the reservoir 200 from falling below atmospheric pressure. The air is prevented from entering around the supply tube 430 and into the transducer chamber 403 by the seal created between the sealing teeth 412 and the supply tube 430. The jetting tube 432 may be primed by slightly pressurizing the reservoir 200 to cause the reagent fluid to travel through the supply tube 430 and into the jetting tube 432. Once primed, the fluid is prevented from substantially withdrawing from the jetting tube 432 by the surface tension of the reagent fluid at the orifice 433.

The transducer activation pulse is conducted to the contact pins 422 of the jetting head 400. The contact pins 422 communicate the high voltage pulse to the electrodes 437, 436 of the transducer 434 with polarity such that the concentrically mounted transducer 434 expands. The rate of expansion is controlled by the rise time of the high voltage pulse which is preset to generate a rapid expansion. The expansion of the transducer 434 causes the jetting tube 432, which is epoxied to the transducer 434, to also expand. The expansion of the tube 432 generates an acoustic expansion wave interior to the tube 432 which travels axially towards the orifice 433 and towards the fluid receiving aperture 431. When the expansion wave reaches the orifice 433, the reagent fluid is partially drawn inwardly. However, the surface tension of the fluid acts to inhibit substantial inward fluid movement.

When the expansion wave reaches the end 431 of the tube 432, the expansion wave is reflected and becomes a compression wave which travels towards the center of the piezo-electric tube 434. The high voltage pulse width is adapted such that when the reflected compression wave is beneath the piezo-electric tube 434, the high voltage pulse falls, resulting in a de-expansion of the transducer 434 and the jetting tube 432. This action adds to the existing acoustic compression wave in the interior of the jetting tube 432. The enhanced compression wave travels toward the orifice causing reagent fluid to be dispensed from the tube 432. The fluid is propelled from the orifice 433 as a small droplet 2 and deposited in the selected mixing cell 904 positioned by the transportation unit 902. One droplet 2 is dispensed for each transducer activation pulse. This mode of dispensing is referred to as the drop on demand mode.

In some instances, the droplet 2 may be accompanied by at least one smaller satellite droplet. However, even if satellite droplets are present, the volume and velocity of the reagent droplets 2 are highly reproducible. This reproducibility allows for precise dispensing of uniform, controllably sized droplets 2 of reagent fluid into the mixing cell 904.

The droplets 2 of reagents impact the mixing cell 904 with sufficient force and volume to cause fluidic mixing of the reagents. Once the desired amounts of the selected reagents are deposited in the selected mixing cell 904, mixing cell 904 is transported to the detection station 906 where the mixed reagents may be extracted for use or analyzed for assay results.

The dispensing system 30 provides numerous advantages based upon the ability of the reagent jetting head 400 to rapidly and reproducibly eject uniform quantities of a wide range of reagents. The reaction times of some chemical processes are dependent upon the volume of the reagents used. The ability of the dispensing system 30 to dispense such minute amounts of reagents thereby reduces the processing time

of certain chemical assays. Furthermore, some chemical assays require a wide range of dilution ratios. Many conventional dispensing systems are unable to dispense the reagents in volume small enough to make the desired assay practical. The dispensing system of the present invention overcomes this disadvantage.

5 In addition to dispensing reagent fluids, certain embodiments may be used for precision printing of reagents onto a printing medium such as filter paper to produce an assay test strip. A printing system 10 using the present invention is represented in Fig. 3. Structure similar in form and function to structure described above will be designated by like reference numerals. The printing system 10 comprises a reagent fluid reservoir 200, a filter 300, a reagent jetting head 400, a jetting head control unit 500, an
10 interface 600, a computer 700, and an x-y plotter 800.

The x-y plotter 800 is a commercially available pen plotter, mechanically modified in a conventional manner such that the pen is replaced with the jetting head 400. The general operation and structure of the plotter 800 will not be described in detail. The plotter 800 accepts commands from the computer 700 thru a standard RS-232 serial interface contained within the interface unit 600. The plotter 800 processes the
15 commands and produces control signals to drive an x-axis motor (not shown) and a y-axis motor (not shown). The x-axis motor is used to position the jetting head 400 and the y-axis motor is used to position a drum (not shown) to which the printing target 1 is attached.

The plotter 800 produces a pen down signal PENDN. This signal is applied to the control unit 500 and indicates that the plotter 800 is ready to begin a printing operation.

20 The control unit 500 also receives control signals from the interface unit 600. These signals include signals HIGHER*, LOWER* to control the magnitude of the pulse applied to the transducer 434; a reset signal RST to reset the control unit 500; and a series of print signals PRT*. The generation of these signals will not be described in detail since their production is performed by the conventional interface unit 600.

The jetting head 400 and fluid supply system 200, 300 are initialized and operate substantially as
25 described above. The jetting head control unit 500, shown in Figs. 5a - 5e comprises a print control circuit 510, a pulse generator 530, a high voltage supply 540, and a strobe pulse generator 560. The control unit 500 also comprises a power supply. However, since the power supply is of conventional design it will not be shown or described in detail.

The print control circuit 510 receives the pen down signal PENDN from the plotter 800 and comprises a
30 transistor Q100, a one-shot circuit U100, two NAND-gates U101, U102, a line decoder multiplexer U107 and four inverters U103-U106. The pen down signal PENDN is applied to the base of the transistor Q100 by resistors R100, R101 and diode D100. The emitter of transistor Q100 is tied to ground and the collector is connected to the +5 volt supply by resistor R102.

The one-shot U100 comprises inputs A, B and an output Q. The B input of the one-shot U100 is
35 connected to the collector of the transistor Q100 and the A input is tied to ground. The time period of the pulse produced by the one-shot U100 is determined by a resistor R104, a variable resistor R105 and a capacitor C100. The output Q of the one-shot U100 is combined with the collector output of the transistor Q100 by the NAND-gate U101 and then inverted by the NAND-gate U102. The circuit is operative to produce an adjustable delay in the application of the pen down signal PENDN to the control unit 500.

40 The line decoder U107 is circuited to function as a 3 input AND-gate. The output of the NAND-gate U102 is applied to the first input of the decoder U107; the print signal line PRT* comprising a series of pulses from the interface unit 600 is applied to the second input; and a jetting head ON/OFF signal from switch S1 is applied to the third input. The inverter U106 inverts the output of the line decoder U107 to generate the print control signal PRT* and the inverters U103-U105 invert the control signals LOWER*,
45 HIGHER*, and RST signals, respectively.

The high voltage supply 540, shown in Fig. 5b, provides +175 volts DC to produce a maximum pulse of +150 volts peak to peak at the reagent jetting head 400. The high voltage supply 540 comprises differential amplifier U12 and transistors Q1, Q2, Q13, Q14. A stable reference voltage of -2.5 volts DC is
50 produced at the junction of a resistor R13, connected to the -15 volt supply, and a diode CR6, connected to ground. The reference voltage is combined with a resistor R14 to produce an adjustable, stable voltage reference for the amplifier U12. The reference voltage is applied to the inverting input of the amplifier U12 through a resistor R11. The noninverting input of the amplifier U12 is connected to ground by a resistor R12. The amplifier U12, in combination with a feedback resistor R10, produces an output signal proportional to the difference of the voltage reference signal and the ground potential.

55 The output of the amplifier U12 is applied to the base of the transistor Q2 whose collector is connected to the +15 volt supply. The signal produced at the emitter of the transistor Q2 is applied to the base of the transistor Q1 through resistors R8, R6, R5, a transformer L1 and diodes CR4, CR2, CR1. The emitter of the transistor Q1 is connected to ground and the collector is connected to the +15 voltage supply through the

transformer L1. A diode CR3 connects the collector of the transistor Q1 to the junction of the resistor R5 and the diode CR4. The transistor Q1 is biased for proper operation by resistors R7, R6, R5. The resistor R7 and a capacitor C22 connect the junction of the resistor R8, R6 to the +15 voltage supply.

The transistor Q1 and the transformer L1 form a "flyback" blocking oscillator. Any increase in current supplied by the transistor Q1 produces an increase in energy transferred through the secondary winding of the transformer L1 and diode CR5. Therefore, an increase in current supplied by the transistor Q1 results in an increase in power available to the high voltage output. The diodes CR1-CR4 form a "Baker clamp" which prevents transistor Q1 from saturating. The clamp thereby avoids transistor storage time.

The diode CR5 is connected to a multiple pi filter formed by the inductors L3, L2, capacitors C24, C21, C41 and resistors R29. The multiple pi filter attenuates ripple and switching spikes in the signal supplied to the transistor Q13 which produces the high voltage output $V+ +$. A resistor R64 connects the base of the transistor Q13 to the emitter and to the resistor U29. The base is also connected to the collector of the transistor Q14 by a resistor R65. The base of the transistor Q14 is connected to the +15 volt supply by a resistor R67 and to ground by a resistor R66. The emitter of the transistor Q13 provides a signal HV SENSE which is fed back to the inverting input of the amplifier U12 through a resistor R9. The high voltage output $V+ +$ is produced at the collector of the transistor Q13. The proper biasing of the transistor Q13 is provided by resistor R64 and the biasing circuit comprising the transistor Q14, resistors R67, R66, R65.

The pulse generator 530, shown in Figs. 5d, 5e, comprises an opto-isolator U18, a one-shot U23, a digital to analog (D/A) converter U30 and two binary counters U24, U25. The pulse generator 530 accepts control signals PRT*, LOWER*, HIGHER*, RST and produces the activation pulse which is applied to the transducer 434. In normal operation, the PRT* control signal is supplied to the opto-isolator U18 by a jumper JMP between contact points E5, E6. The opto-isolator U18 is of conventional design and comprises a light emitting diode (LED) circuit and a photo-element circuit. A resistor R15 operates as the load resistor for the LED circuit of the isolator and a capacitor C25 suppresses transient noise on the voltage supply to the isolator U18. The output of the isolator U18 is applied to one input of the one-shot U23 whose time constant is adjustably determined by resistors R38, R25 and a capacitor C30. The pulse from the non-inverting output of the one-shot U23 is fed to the base of a transistor Q9. A resistor R39 sets the approximate base current of the transistor Q9 which is used as a level shifter for converting the CMOS signal level to the +15 volt DC signal level.

The control of the rise and fall rates of the pulse generator 530 is accomplished by directing a pair of current source transistors Q11, Q12 to charge and discharge a capacitor C57. The transistor Q11 is operative as a source of current and the transistor Q12 is operative as a sink for current. A transistor Q10 controls the level of the current by applying an appropriate bias current through a resistor R56 to the base of the transistor Q11. The biasing of the transistors Q11, Q12 is critical to the proper rise and fall rates. Therefore precision voltage references CR13, CR15 are used to provide respective bias reference voltages. A temperature compensation network is formed from zener diodes CR14, CR16 and resistors R55, R54 to maintain stable operation of the transistors Q11, Q12, respectively. The variable resistors R49, R52 may be used to adjust the fall time and rise time, respectively, of the output pulse applied to the reagent jetting head 400. A plurality of resistors R45, R46, R47, R48, R49, R51, R52, R53, R56, R57, R58 are used to properly bias the transistor Q10, Q11, Q12 and capacitors C55, C60 are circuited to maintain stability of the circuit.

The impedance of the output stage of the rise and fall circuitry Q10, Q11, Q12 is very high. With such a high impedance, circuit elements attached to the capacitor C57 could affect the linearity of the rise and fall time constants. Therefore, an FET input operational amplifier U32 is used as an impedance interface. The amplifier U32 is configured in the noninverting mode and circuited with capacitors C58, C59 for stability.

The output of the amplifier U32 is applied to an inverting amplifier U31 by means of a resistor R62. The amplifier U31 inverts and conditions the pulse control signal with the aid of resistors R59, R60. Resistors R61, R63, connected to the -15 voltage supply, provide a means for adjusting the DC level offset of the amplifier U31 output signal. Capacitors C51, C52 are connected to enhance the performance and stability of the circuit.

The output of the amplifier U31 is applied by means of a resistor R41 to the positive voltage reference signal input REF(+) of the D/A converter U30. The negative voltage reference signal input REF(-) is tied to ground by a resistor R40. The D/A converter U30 produces output signals IOUT, IOUT* which are proportional to the difference between the positive and negative voltage reference signal inputs REF(+), REF(-). Capacitors C48, C49, C50 are connected to the D/A converter U30 to enhance stability.

The D/A converter outputs IOUT, IOUT* are also proportional to an 8-bit binary value applied to inputs B1-B8. The binary value is supplied by the counters U24, U25 which are controlled by the function signals LOWER*, HIGHER* and RST. The LOWER* signal and the HIGHER* signals are applied to the count up and

count down inputs CU, CD of the counter U24 by means of opto-isolators U19, U20. The carry and borrow outputs CY, BR of the counter U24 are connected with the count up and count down inputs CU, CD of the counter U25. The reset inputs RST of both counters U24, U25 receive the RST signal by means of an opto-isolator U21. Resistors R16, R17, R18 are used as load resistors for the LED circuits of the isolators U19, U20, U21 and capacitors C26, C27, C28 are used to enhance the stability of the isolator circuits.

The counters U24, U25 may optionally be preloaded to the selected 8-bit binary value through input lines TP0-TP7. The input lines TP0-TP7 are normally biased to the logical high signal state by resistive network U22. The selected binary value is loaded into the counters U24, U25 by pulling the respective inputs TP0-TP7 low and applying an external, active low, load signal EXT LOAD to pin TP8. The load signal pin TP8 is connected to the load inputs LOAD of the counters U24, U25 and conditioned by a clipping circuit comprised of diodes CR9, CR10 and a pull-up resistor of the resistor network U22.

The noninverted and the inverted outputs IOU, IOU⁻ are connected to the inverting and noninverting inputs of a differential amplifier U29. The output of the amplifier U29 is fed back to the inverting input by a resistor R50. The amplifier U29 converts the current output of the D/A converter U30 to a voltage output. Capacitors C56, C47 are provided to enhance circuit stability.

The output of the amplifier U29 is applied to the noninverting input of the amplifier U28. The output of the amplifier U28 is fed back to the inverting input by means of a capacitor C46 and a resistor R37. The inverting input is also connected to ground by a resistor R36. To enhance the frequency response of the amplifier U28, a resistor R43 and a capacitor C54 are connected between the frequency compensation input FC and ground. An adjustable DC offset is provided by connecting the output offset inputs OF, OF with a variable resistor R42. The wiper of the resistor R42 is connected to the high voltage power supply output V⁺.

The output of the amplifier U28 is also connected to the base of a transistor Q4 and through diodes CR11, CR12 to the base of a transistor Q7. The transistor Q4, Q7, Q3 and resistors R30-R35 form an output circuit capable of driving high capacitive loads at high slew rates and wide bandwidth. The variable resistor R31 may be used to set the maximum current through the bias network R30, R33 by measuring the voltage drop across resistor R35.

The strobe generator 560 produces a strobe pulse and comprises transistors Q101-Q105 and a one-shot circuit U108. The strobe intensity is determined by the circuit comprising the transistors Q101-Q104 and resistors R109-R115. The circuit is connected to the anode of the LED 900 and receives two inputs from the interface unit 600 to produce four levels of light intensity in the LED 900.

The activation and duration of activation of the LED 900 is determined by the one-shot U108 and the transistor Q105. The one-shot U108 comprises inputs A, B and an output Q. The strobe signal STROBE is applied to the B input from the interface unit 600. The duration of the one-shot U108 output pulse is controlled by the adjustable RC network R107, R108. The output Q is applied to the base of the transistor Q105 by resistor R108. The collector of the transistor Q105 is connected to the cathode of the LED 900 to draw current through the LED 900.

The computer 700, control unit 500 and plotter 800 must be initialized. The initialization of the computer 700 and the plotter 800 will not be discussed since these units are of conventional design and operation.

To initialize the jetting head control unit 500, the computer 700 directs the interface unit 600 to issue a reset command. The reset signal RST is conducted to the control unit 500 whereupon the counters U24, U25 are cleared. The computer 700 then retrieves from its memory, or by conventional operator input, the desired digital setting for the D/A converter. This setting may also be calculated from data and may be tailored to specific sizes of jetting heads 400 or reagent fluids. The computer 700 then issues a series of commands, through the interface unit 600, to increment or decrement the counters U24, U25 to correspond to the desired binary setting. If the command directs that the counters are to be raised, then the HIGHER signal is applied through the opto-isolator U20 to the count up CU input of the counter U24. Similarly, if the command directs that the counters are to be lowered then the LOWER signal is applied through the opto-isolator U19 to the count down CD input of the counter U24. Since the carry and borrow outputs CY, BR of the counter U24 are connected to the count up and count down inputs CU, CD, respectively, of the counter U25, the digital setting applied to the D/A converter U30 may range from 0 to 255. Alternately, the counters U24, U25 could be initialized to a desired setting by loading the binary value on the lines TP0-TP7 and strobing the EXT LOAD line.

Once the control unit 500 and the plotter 800 are initialized, the printing cycle may begin. The computer 700 issues a command to the interface unit 600 to produce the series of PRT signal pulses. The computer 700 then commands the plotter 800 to print, for example, a line along a selected path. The plotter 800 positions the jetting head 400 and target 1 and issues the pen down signal PENDN. The signal is delayed by the print control circuit 510 to ensure that the target 1 is properly positioned. At the expiration of the

delay, the signal is ANDed with the closed-enable switch S1 and the series of print pulses PRT. The result of the AND operation is the application of the PRT pulses to the pulse generator circuit 530.

The PRT signal is applied through the jumper JMP to the opto-isolator U18 and then to the one-shot U23. The one-shot U23 produces a pulse signal which is then converted from CMOS signal levels to the 15 volt DC signal level by the transistor Q9. The rise and fall circuitry comprising Q10, Q11, Q12 converts the square wave pulse into a pulse having the rise and fall characteristics preset by the resistors R49, R52. The conditioned pulse is then amplified by the amplifier U32 and applied to the amplifier U31.

The amplifier U31 converts the polarity of the conditioned pulse to that acceptable by the D/A converter U30 and supplies an adjustable DC offset. The DC offset is used to counteract possible distortion attributable to the amplifier U31. The distortion arises in that, for the amplifier U31 to be adequately responsive, a small degree of current must flow through the resistor R41. This current creates an offset condition at the output of the amplifier U29 which is then scaled by the D/A converter U30 in correspondence with the binary data. The resistor R63 allows a small amount of current to be applied to the amplifier U31 to control the offset voltage attributable to the current flowing through the resistor R41.

The D/A converter U30 scales the difference between the inputs REF(+), REF(-) using the binary data supplied to input lines B1-B8 to produce a current output pulse IOUT and a current inverted output pulse IOUT*. The two outputs IOUT, IOUT* are fed to the amplifier U29 which convert the current outputs into a single voltage output. The scaled, conditioned pulse is then applied to the output circuit comprising the amplifier U28 and the transistors Q3, Q4, Q5, Q6, Q7. The circuit produces a high voltage pulse with the aforementioned rise and fall characteristics to drive the piezo-electric transducer 434.

The high voltage pulse is applied to the transducer 434 and causes a droplet 2 of fluid to be propelled onto the target 1. Since the pen down signal PENDN is still applied, additional droplets 2 are produced from the jetting head 400. The plotter 800 moves the jetting head 400 and target 1 along the desired path during the emission of the droplets 2 to produce the desired printed line. When the printing is complete, the plotter 800 removes the pen down signal PENDN and the droplet emission stops. Of course it should be understood that dots, circles and the like could be produced by appropriate positioning of the target 1 and jetting head 400.

The size and uniformity of the droplets 2, as well as the presence of any satellite droplets, may be observed with the aid of the scope 950 and the LED 900. The scope 950 and the LED 900 are positioned such that the droplets 2 pass between the scope 950 and the LED 900 and within the focal range of the scope 950. The strobe pulse when applied to the LED 900 causes the LED 900 to momentarily flash. The timing of the activation and the width of the pulse may be adjusted such that the flash occurs when the fluid, expelled in response to the high voltage pulse, is between the scope 950 and the LED 900. The dispensed quantity of fluid may then be observed in flight or at or near the moment of separation from the orifice 433. Corrections based on the observation may then be made to the system 10.

Since each droplet 2 is small in volume, the droplet 2 may be rapidly absorbed by the target 1, thereby allowing rapid and precise placement of a variety of reagents on the target 1 with reduced drying time and reduced potential of fluidity mixing. In addition, the ability to place small droplets 2 in a precise manner enables the target 1 to be printed in a high density matrix with a variety of reagents as isolated matrix elements.

In some printing applications, particularly when printing fluids of flow viscosity and surface tension, it may be desirable to force the fluid through the jetting tube 432 under pressure and allow the vibrations produced by the transducer 434 to break the emitted fluid stream into precise droplets 2. Under this mode of printing, the emission of droplets 2 can not be stopped by cessation of the transducers activation pulse. It is therefore necessary to prevent fluid emission by other means. One preferred means of momentarily stopping emission of the droplets is shown schematically in Fig. 4. In this arrangement, structure similar to structure represented in Fig. 3 in form and function, is represented by like reference numerals.

The arrangement, generally represented by the numeral 20, includes a closed reagent recirculation system comprising a normally close three way valve 970, a sump 960 and a recirculation pump 980. In the continuous mode, the reagent fluid is forced out the orifice 433 by hydraulic pressure and broken into a series of substantially uniform droplets 2 by movement of the transducer 434. A regulated, filtered air supply 100 is used to pressurize the reagent fluid reservoir 200. The reagent fluid within the reservoir 200 may optionally be agitated by a magnetic stirrer unit 990. This is especially useful for reagent fluids comprising suspended particles.

The three-way valve 970 comprises a common channel, a normally open channel and a normally closed channel. The fluid is forced through the filter 300 and applied to the normally closed channel of the valve 970. When the normally closed channel is closed, the normally open channel of the valve 970 functions as a vent for the reagent jetting head 400. The common channel is connected to the reagent supply tube 430

of the jetting head 400. The reagent supply tube 430' is also connected to the sump 960'.

In operation, the normally closed channel is opened by an appropriate signal supplied by the computer 700 which also closes the normally open channel. When the normally closed channel is opened, fluid is permitted to pass to the sump 960 and to the jetting head 400. The sump 960 collects the reagent fluid not transferred to the jetting head 400. The sump 960 supplies the collected fluid to the inlet side of the recirculating pump 980 which returns the fluid to the reservoir 200. The returned fluid is then mixed with the contents of the reservoir 200 and is available for recirculation.

When operating in the continuous mode, rather than interrupt the continuous stream of print pulses to the jetting head 400, the printing may be momentarily stopped by closing the normally closed channel of the valve 970. The closing of the normally closed channel stops the flow of reagent fluid to the jetting head 400 and allows the jetting head 400 to vent to atmospheric pressure. With the fluid supply blocked, the transducer 434 is unable to expel further droplets 2. Thus, if positioning of the target 1 by the plotter 800 requires a longer time interval than the time between droplet 2 emission, the computer 700 may close the normally closed channel of the valve 970. The plotter 800 may then position the target 1 or position a new target 1 as desired.

When printing, the active ingredient of the reagent is tailored to achieve a desired concentration per unit area on the target 1. However, to a certain extent the final concentration per unit area can be adjusted by varying the density of the droplets 2 printed on the target 1. The preferred embodiment is particularly well suited to this application due to its ability to print precise, discrete pels of reagent.

A second preferred embodiment of the jetting head is illustrated in Figs. 6a-6b and is generally represented as 400'. The jetting head 400' comprises housing formed into three sections 401', 402', 403'. The housing section 403' comprises a recessed region which forms the reagent fluid reservoir 200' when the housing section 403' is positioned against housing section 402'.

The jetting head 400' further comprises a piezo-electric transducer 434' and a reagent jetting tube 432' similar to those of the first embodiment. The jetting head 400' and the transducer 434' are most clearly shown in Fig. 6b. The jetting tube 432' defines an orifice 433' at one end and a reagent fluid receiving aperture 431' at the other end. The transducer 434' is mounted to the jetting tube 432' concentrically about the mid-region of the tube 432' with epoxy.

The transducer 434' and the jetting tube 432' are positioned in channels 420', 418', 416' located in the housing sections 402', 401'. The channel 416' comprises a plurality of sealing teeth 412' operative to engage and seal against the fluid receiving end 431' of the jetting tube 432'. The channel 416' is connected to the reagent fluid supply channel 430'. The supply channel 430' is connected with the fluid reservoir 200' by means of an aperture 431' through the housing section 402', shown in Fig. 6b.

The reservoir 200' comprises a flexible reservoir lining 201' adapted to contain the reagent fluid. The lining 201' comprises one aperture which is connected to the housing 402' to allow the fluid to pass from the lining 201'. A vent (not shown), located in the housing 403', allows the space between the reservoir 200' and the lining 201' to be vented or pressurized. A filter 300' is positioned within the aperture 202' to trap unwanted particulate foreign matter.

Electrical pulses are supplied to the transducer 434' by means of two contact pins 422'. The pins 422' are inserted through respective apertures 419' of the housing section 402' and respective apertures 421' of the housing section 403'. Two thin electrically conductive strips 410', 411', shown in Fig. 6b, are used to connect the transducer 434' with the contact pins 422'. A protective shield 405' extends from the housing position 403' to partially isolate the protruding portions of the contact pins 422'.

The function and operation of the jetting head 400' is similar to that of the jetting head 400 and therefore will not be discussed in detail. The collapsible inner lining 201' of the reservoir 200 allows the jetting tube 432' to be primed by pressurizing the reservoir 200' through the vent 205'. Once primed, the jetting head 400' may be used as described above in reference to the jetting head 400.

The jetting head 400' provides an advantage in that the entire fluidic system is contained in one housing. Such containment allows for fast and efficient replacement of the jetting heads without fluid contamination problems.

A third preferred embodiment of the jetting head is shown in Fig. 7 and generally represented as 400". The jetting head 400" comprises a housing 403", a reagent fluid supply tube 406", a piezo-electric transducer 434" and an orifice plate 404". The housing 403" defines a conically shaped fluid chamber 432". An orifice plate 404", defining an orifice 433", is fastened to the housing 403" such that the orifice 433" is located at or near the apex of the conical fluid chamber 432".

The fluid feed tube 406" is attached to the housing 403" and defines a supply channel 430". The supply channel 430" is in fluid communication with the fluid chamber 432" by means of a connecting channel 431". The base of the fluid chamber 432" is formed by the disc-shaped transducer 434". The transducer 434" is

held in position by a hold down plate 402 attached to the housing 403. The electrical connections to the transducer 434 are of conventional design and are therefore not shown. The housing 403 further comprises a threaded aperture 406 for mounting the jetting head 400.

The jetting head 400 operates in a manner similar to the jetting heads described above. However, in this jetting head the transducer 434 is normally disk shaped. When the electrical pulse is applied, the transducer 434 bends slightly, thereby altering the volume of the conically shaped jetting chamber 432. The change in volume of the chamber 432 causes the expulsion of fluid through the orifice 433 and the intake of fluid through the supply channel 430 as described in reference to the jetting head 400.

A fourth preferred embodiment of the jetting head is shown in Fig. 8 and is generally represented as 400'. The jetting head 400' is very similar in form and function to the jetting head 400 and will not be described in detail. The jetting head 400' comprises two symmetrical housing sections. The sections may be connected together by means of apertures 409' and screws, not shown. When assembled, the housing sections 404', 402' form a T-shaped supply channel 410'.

In operation, the jetting head 400' functions in a manner similar to the jetting head 400. The jetting head 400' is especially suited for use in the continuous mode, but may also be used in the drop on demand mode. In the continuous mode, the fluid is circulated continuously through the supply channel 430' allowing the jetting tube 432' to withdraw as much fluid as required.

By way of illustrating and with no limitations intended the following information is given to further illustrate the above described embodiments. The computer 700 is an IBM Corporation Personal Computer with 640 kbytes of RAM memory. The interface unit 600 is a Burr Brown interface unit model number PC 20001. The plotter 800 is manufactured by Houston Instrument as model number DMP-40. Communication between the plotter 800 and the interface unit 600 is performed through a standard asynchronous serial communication port.

The electrical pulse applied to the jetting head 400 to activate the transducer 434 comprises a rise time of approximately 5 usecs, a fall time of approximately 5 usecs and a pulse width of approximately 35 usecs. When the transducer 434 is operated in the drop on demand mode, the voltage potential of the pulse is 60 volts plus or minus 10 volts and the pulse frequency can be up to 4 khz. When the transducer 434 is operated in the continuous mode, the voltage potential of the pulse is 30 volts plus or minus 10 volts and the pulse frequency can be up to 10 khz.

The jetting tube 432 is manufactured from a pyrex glass tube and measures .027 inches outside diameter and .020 inches inside diameter. The tube is drawn to a closed taper in an electric furnace. The tapered end is then cut and ground to a desired orifice opening of .002 to .004 inches in diameter. The tube is cut to a final length of .945 inches in the case of the dispenser embodiment and ultrasonically cleaned in acetone. After being cleaned and dried the large end of the tube is fire polished. If desired, the orifice end of the tube may receive a coating, such as a hydrophobic polymer, to enhance droplet separation from the tube.

The supply tube 430 is formed from .023 inch inside diameter and .38 inch outside diameter polyethylene tubing produced by Intramedic Corp. as model number #14 170 11B. During assembly, one end of the tubing is stretched over a warm tapered mandrel. The stretched end of the supply tube 430 is then inserted over the large fire polished end of the jetting tube 432. The assembly is then cleaned and baked in a circulating air oven at 50°C. for 10 minutes.

The transducer 434 was purchased from Vernitron of Cleveland, Ohio as model number PZT-5H. The electrodes 437, 436 are comprised of nickel and are separated from each other on the outer surface of the transducer by approximately .030 inches. The jetting tube 432 is inserted into the cylindrical piezo-electric tube 434 and secured with epoxy manufactured by Epoxy Technology of Bellenca, Massachusetts as model number 301. The epoxy is applied at the junction of the tube 432 and transducer 434 with a syringe. The epoxy flows along the tube 432 inside the transducer 434 by capillary action. The assembly is then baked in a circulating air oven at 65°C. for one hour to cure the epoxy.

The contact pins 422 are secured to one of the housing sections 402, 404 with a drop of epoxy. The transducer jetting tube 434, 432 is placed in the housing such that the orifice end 433 of the tube 432 protrudes approximately .030 inches from the housing 403, 404. A drop of silver epoxy is placed between each contact pin 422 and the transducer 434 to ensure a secure electrical connection. Epoxy is also applied to the junction of the housing 402, 404 and supply tube 430. The other section of the housing 402, 404 is then screwed into place.

The periphery of the housing 402, 404 is sealed with a capillary sealer such as cyclohexanone. Epoxy is then added around each contact pin 422 and around the orifice end 433. The assembly is then baked in a circulating air oven at 65°C. for one hour.

The filter 300 is formed from a polyester mesh with 30 um pores and positioned in a polypropylene

housing. The air pressure supplied to the reservoir 200 during continuous printing operations is regulated at approximately 10 to 30 psi.

The reagents used have the following characteristics:

Printing (drop on demand mode):

5 Fluid viscosity range: 1 - 30 centipoises

Fluid surface tension: 20 - 70 dyne/cm

Printing (continuous mode):

Fluid viscosity range: up to 50 centipoises

Fluid surface tension: not measured

10 Dispensing (drop on demand mode):

Fluid viscosity range: 2 - 30 centipoises

Fluid surface tension: 20 - 70 dyne/cm

A measure of the performance and selected operating characteristics for a typical jetting head are presented in Figs. 9-11. Fig. 9 is a graph of the mass of a droplet as a function of droplet emission frequency for three fluids. The viscosity of the fluids were 1, 5 and 24 centipoise and the transducer excitation pulse width was 35 microseconds. As shown in Fig. 9, the higher fluid viscosity results in a more stable operating performance of the jetting head. Fig. 10 is a graph of droplet velocity as a function of droplet emission frequency for fluid viscosities of 1, 5 and 24 centipoise. The log of the total fluid weight as a function of the log of the number of droplets emitted is shown in Fig. 11. The fluid used has a viscosity of 2 centipoise, a surface tension of 20 dynes/cm, and a density of .8 grams/cc. The transducer excitation pulse was 80 volts and the excitation frequency was approximately 711 Hz.

Some blood typing reagents and some allergen reagents have very low viscosities and surface tensions. Although in some cases viscosity modifiers, such as glycerol, dextran, glucose, and the like, may be added to increase the viscosity, a few reagents are adversely affected by such modifiers.

25 Developing stable and reproducible demand mode jetting is difficult with very low viscosities. Although droplet emission can be established at some fundamental frequencies, the droplets dispensed may have small satellite droplets which reduce the accuracy for metering and dispensing applications. However, even with the satellite drops, sufficient reagent is adequately delivered for most print applications without a substantial decrease in print quality.

30 Glycerin may be used as a viscosity modifier to improve jetting reliability and to prevent obstruction of the orifice arising from evaporation of the reagent fluid components. Glycerin has been found especially beneficial for those reagents containing particulate material. The evaporation of the fluid component results in a concentration of glycerin located at the orifice. The plug of glycerin substantially prevents further evaporation of the reagent fluid. During the next activation cycle of the transducer, the plug of glycerin is expelled from the orifice.

35 When operating in the dispensing mode the volume of the droplets can be varied to substantially uniformly contain from 100 pico-liters to 1 micro-liter. The droplets can be produced at a rate of approximately 1 khz to 8 khz. When operating in the printing mode the size of the pel made by each droplet measures approximately .001-.012 inches in diameter.

40 A copy of the program used in the computer 700 for a printing operation is attached hereto as Appendix A. The values, manufacturer and manufacturing part number of the circuit components of the jetting control unit 500 are substantially as follows:

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Ref. Numeral of Component	Description and Value	Manufacturer and Part No.
R39, 45-48, 57, 58	RES. 10KOHM, WATT5% C.F.	
R66	RES. 150OHM, WATT5% C.F.	
R3	RES. 15KOHM, WATT5% C.F.	
R34	RES. 16KOHM, WATT5% C.F.	
R50	RES. 2.4KOHM, WATT1% C.F.	DALE RLO79242G
R13, 23, 36, 40, 41	RES. 2.4KOHM, WATT5% C.F.	
R56	RES. 20KOHM, WATT5% C.F.	
R8	RES. 220OHM, WATT5% C.F.	
R6	RES. 27OHM, WATT5% C.C.	
R7, 12, 25	RES. 2KOHM, WATT5% C.F.	
R67	RES. 3.6KOHM, WATT5% C.F.	
R51, 53	RES. 3.9KOHM, WATT5% C.F.	
R29	RES. 300KOHM, WATT5% C.F.	
R61	RES. 30KOHM, WATT1% C.F.	DALE RLO79303G
R15-18, 26-28, 54, 55, 64	RES. 4.7KOHM, WATT5% C.F.	
R62	RES. 45.3KOHM, WATT1% C.F.	DALE RN55D4532F
R30, 33	RES. 47OHM, WATT5% C.F.	
R21	RES. 470OHM, WATT5% C.F.	
R19	RES. 47KOHM, WATT5% C.F.	
R35	RES. 510OHM, WATT5% C.F.	
R43	RES. 6.2KOHM, WATT5% C.F.	
R60	RES. 7.5KOHM, WATT5% C.F.	
R37	RES. 75KOHM, WATT5% C.F.	
R9	RES. 76KOHM, WATT1% C.F.	DALE RN60D7622F
R11	RES. 820OHM, WATT5% C.F.	
U2, 11, 14, 16, 22	RES. DIP NETWORK. 47KOHM	CT9 761-1R47K
C21, 41, 45	CAP. AXIAL 1MF@250VDC	MALLORY #TC56
C24	CAP. AXIAL 220MF@250VDC	MALLORY
C10	CAP. AXIAL ALUM ELEC.	LP2219250C7P3
	4700 0MF@25VDC	MALLORY
C1, 2, 3, 55, 60	CAP. RADIAL DIPPED TANT.	TCG472UC25NIC
	10MF@25VDC	KEMET
C53	CAP. RADIAL DIPPED TANT.	T350E106M025AS
	1MF@35VDC	KEMET
C36	CAP. RADIAL DIPPED TANT.	T350A105K035AS
	47MF@10VDC	KEMET
		T350H566MC10AS

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Ref. Numeral of Component	Description and Value	Manufacturer and Part No.
C54	CAP.RADIAL SILV MICA 100PF300VDC	KAHGAN SD5101J301
C57	CAP.RADIAL SILV MICA 20PF300VDC	KAHGAN SP12200J301
10 C49	CAP. RADIAL SILV. MICA 39PF300VDC	KAHGAN SP12390J301
C39	CAP.RADIAL X7R MLC .015MF@50VDC	KEMET C315C102K1R5CA
15 C6	CAP.RADIAL X7R MLC .022MF@50VDC	KEMET C315C223K5R5CA
C30,35,37	CAP.RADIAL Z5U MLC .015MF@50VDC	KEMET C315C153K5R5CA
C4,7	CAP.RADIAL 25U MLC .01MF@50VDC	KEMET C315C103K5R5CA
20 C4,5,6,9,11-19, 22,23,25-28 C31-34,37,42,43 47,48,50-52	CAP.RADIAL 25U MLC .22MF@50VDC	KEMET C322C224M5U5CA
25 C56,58,59		
C46	CAP.VARI.2-12PF.	JOHANSEN #9626
CR7,8,9,10, 11,12,17	DIODE SIL.	ITT.FAIRCHLD.1N4148
30 CR1,2,3,4 CR5 CR6,13,15 CR14,16 U6,13,15,17	DIODE SIL.FAST DIODE SIL.FASTHIVOLT DIODE SIL.REF.2,500VDC DIODE SIL.ZENER3.8V.25WATT	GENL.INST.EGP10D GENL.INST.UF4007 NATL.SEMI-LM3852-2.5 MOTOROLA 1N4622A
35 Q2,9,12 Q8,10,11 Q4 Q7 Q1	SWITCH 8 POSITION DIP TRANSTOR.COMMON NPN TRANSTOR.COMMON PNP TRANSTOR.HIVOLTHIFREQ.NPN TRANSTOR.HIVOLTHIFREQ.PNP TRANSTOR.HIVOLTHIINPN	CTS 206-8 MOTOROLA 2N2222A MOTOROLA 2N2907A MOTOROLA MPSU10 MOTOROLA MPSU60 TI,MOTOROLATIP48
40 Q3,14 Q13 U5,27 U23,26 U7-10	TRANSTOR.HIVOLTHPN2N3439 TRANSTOR.HIVOLTPNP IC 1-SHOT 74HC221 IC 1-SHOT 74LS221 IC COMPARATOR 74HC688	MOTOROLA 2N3439 MOTOROLA MJE5731 NATL.SEMI MM74HC221N NATL.SEMI DM741S221N NATL.SEMI MM74HC688N
45 U30 U24,25 U28 U1 U4 U3	IC CONVERTER DAC0800 IC COUNTER 74HC193 IC HI SLEW HI VOLT OP AMP IC HYBRID DC/DC CONVERTER IC OC DRIVER SN7406 IC OCTAL LATCH 74HC374	NATL.SEMI DAC0800LCN NATL.SEMI MM74HC193N BURR-BROWN 3584JM BURR-BROWN MODEL 724 NATL.SEMI DM7406N NATL. MM74HC374N
50 U12,29,31,32 U18,19,20,21 R24,42,63 R38,49,52 R20	IC OP AMP LF256 IC OPTO ISOLATOR POT100KOHM±WATT10% POT10KOHM±WATT10% POT25KOHM±WATT10%	NATL.SEMI LF256H HEWLETT-PCKRD HCPL2300 BOURNS 3622-1-104 BOURNS 3622W-1-103 BOURNS 3622W-1-253
55 R14,31	POT2KOHM±WATT10%	BOURNS 3622W-1-202

Ref. Numeral of Component	Description and Value	Manufacturer and Part No.
5 VRI	REGULATOR 5VDC	NATL.LM340T-5.0
R10	RES.1MEGOM $\frac{1}{4}$ WATT5% C.F.	
R2,4	RES.1.2KOHM $\frac{1}{4}$ WATT5% C.F.	
R32	RES.1.6KOHM $\frac{1}{4}$ WATT5% C.F.	
R44	RES.1.8KOHM $\frac{1}{4}$ WATT5% C.F.	
R1	RES.10MEGOM $\frac{1}{4}$ WATT5% C.F.	
10 R5,R22	RES.100HM $\frac{1}{4}$ WATT5% C.F.	
R65	RES.100KOHM $\frac{1}{4}$ WATT5% C.F.	
R59	RES.10KOHM $\frac{1}{4}$ WATT1% C.F.	DALE RN55D1002F
R100	RES.270OHM	
R101,108	RES.470OHM	
15 R102,103	RES.1KOHM	
106,109,110		
R104	RES.4700OHM	
R105	PCT.100KOHM	
R107	POT.10KOHM	
20 R111,113	RES.220OHM	
R112	RES.22OHM	
R114,115	RES. 47OHM	
C100	CAP.10MF035 VFC	
C108	CAP.10000 PF	
25 D100	DIODE	1N4148
Q100,105	TRANSTOR	2N2222
Q101,102	TRANSTOR	2N3906
Q103,104	TRANSTOR	2N3904
U100,U108	IC I-SHOT	74LS123
30 U103,104	IC INVERTOR	74LS04
105,106		
U108	IC LINE DECODER	74LS138

Of course, it should be understood that a wide range of changes and modifications can be made to the preferred embodiments described above. For example, the transducer could be of a type other than piezo-electric such as magneto-strictive, electro-strictive, and electro-mechanical. It is therefore intended that the foregoing detailed description be regarded as illustrative rather than limiting, and that it be understood that it is the following claims, including all equivalents, which are intended to define the scope of this invention.

APPENDIX

0 268 237

5 Reagent Jet Printer
Reagent Calibration

PAGE 1
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12:26:57

IBM Personal Computer BASIC Compiler V2.00

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Offset  Data  Source Line
70 0030 0006 REM $TITLE:'Reagent Jet Printer' $SUBTITLE:'Reagent Calibration' $LINESIZE:132
0030 0006 'MODULE - "RECAL"
0030 0006
0030 0006 'AUTHOR - M. A. Enervold
0030 0006
0030 0006 'COPYRIGHT (C) 1985 ABBOTT LABORATORIES
15 0030 0006 'REVISION - 2.0 07-01-86 RAE MicroFab modifications
0030 0006 ' - 1.0 02-11-86 RAE Creation of initial code
0030 0006
0030 0006 'SYSTEM - This code can only be compiled by the BASCOM
0030 0006 ' COMPILER, it will not run under the INTERPRETER!!
0030 0006
20 0030 0006 'DESCRIPTION:
0030 0006 ' The reagent calibrate module presents a menu with 12 items arranged
0030 0006 ' in 3 columns of 4 rows. The arrow keys allow movement around the
0030 0006 ' table, the + and - keys increment or decrement values in the first
0030 0006 ' column, and the enter key executes commands in the third column.
0030 0006 ' The second column is an array of ASCII strings representing reagent name,
25 0030 0006 ' concentration, density, and viscosity. The values entered in column one
0030 0006 ' are drop frequency, pulse width, strobe delay, and nozzle number.
0030 0006 ' The commands in the third column are start/stop, load, save, and exit.
0030 0006
0030 0006 'DATA DICTIONARY
0030 0006 '
0030 0006 ' MENU% Pointer to which menu item is active (0-11)
30 0030 0006 ' MENU$(17,1) Array for strings used to display the menu
0030 0006 ' MENU$(17,4) Array for numbers in the menu display
0030 0006 ' DIFF% Differential to save MENU% at arrow key input
0030 0006 ' TYPE% Pointer set during main scan to direct action
0030 0006 ' KEYBUF$ Storage for string input from menu display
0030 0006 ' AS Destination for single keystroke inputs
35 0030 0006 ' FILES String where filename is built for reagent data file
0030 0006 ' REAMEN$ String where reagent name is stored
0030 0006 ' R% Row to display special graphics character in menu
0030 0006 ' C% Column to display special graphics character in menu
0030 0006 ' N% Special graphics character is read into here
0030 0006 ' OLD.AMP.VALUE% Integer value for setting pulse amplitude
40 0030 0006 ' DIG.VAL% Value set to digital port 0 to inc/dec amplitude
0030 0006
0030 0006 SUB REAGENT.CALIBRATE STATIC
0047 0006
0047 0006 DIM MENU$(17,1),MENU$(17,4)
0048 01FE
45 0048 01FE GOSUB INITIALIZE: 'read init. values and set screen
004E 01FE
004E 01FE WHILE TYPE% < 1
0051 0200
0051 0200 TYPE% = 0
0060 0200 AS = ""
50 006A 0204
006A 0204 WHILE AS = ""
0079 0204 AS = INKEY$
0083 0204 IF ACTIVE% = 1 AND DOWNTIME < TIMER THEN GOSUB PEX.BOMM
00AD 0204
0080 0204 VEND
55

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Resgent Jet Printer
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IBM Personal Computer BASIC Compiler V2.00

Offset	Data	Source Line
25 0080	020A	IF AS = CHR\$(13) THEN TYPE1 = 1: 'execute (cr)
00CA	020A	IF AS = "+" THEN TYPE1 = 2: 'increment variable
00E0	020A	IF AS = "-" THEN TYPE1 = 3: 'decrement variable
00F6	020A	IF AS = CHR\$(0) + CHR\$(72) THEN TYPE1 = 4: 'up arrow key
011B	020A	IF AS = CHR\$(0) + CHR\$(80) THEN TYPE1 = 5: 'down arrow key
0140	020A	IF AS = CHR\$(0) + CHR\$(75) THEN TYPE1 = 6: 'left arrow key
30 0165	020A	IF AS = CHR\$(0) + CHR\$(77) THEN TYPE1 = 7: 'right arrow key
018A	020A	IF AS > CHR\$(47) AND AS < CHR\$(123) THEN TYPE1 = 8: 'ascii 0 - z
01C2	020A	ON TYPE1 GOSUB T1, T2, T3, T4, T5, T6, T7, T8
01DB	020A	END
35 01DF	020A	TYPE1 = 0
01E6	020A	EXIT SUB
01EA	020A	REN SPAGE

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5 Reagent Jet Printer
Reagent Calibration

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IBM Personal Computer BASIC Compiler V2.00

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Offset  Data  Source Line
10 01EA 0204 '***** SUBROUTINES FOR THIS MODULE *****
01EA 0204
01EA 0204 T1: '(<cr>) execute command
01EF 0204 IF MENU(12) = 0 THEN TYPE = 0: RETURN: 'exit to print menu, no action
0205 020C ON MENU - 11 GOSUB T1A, T1B, T1C, T1D
021A 020C IF MENU(12) = 0 THEN TYPE = 0
022C 020C RETURN
15 0230 020C T1A: 'start/stop drop flow
0233 020C IF MENU(12,0) = "START" THEN GOSUB START.INX
023A 020C IF MENU(12,0) = "STOP" THEN GOSUB STOP.INX
027F 020C MENU(12,0) = TEMP$
029A 0210 COLOR 0,7:GOSUB DISPMENU
20 02AC 0210 RETURN
02B0 0210 START.INX:
02B5 0210 TEMP$ = "STOP"
02BF 0210 CALL DOT.ON: 'in module PCI
02C3 0210 LOCATE 17,7:COLOR 27,0:PRINT "PRINTING";
25 02F1 0210 ACTIVE1 = 1
02F8 0210 RETURN
02FC 0210 STOP.INX:
0301 0210 TEMP$ = "START"
30 0308 0210 CALL DOT.OFF: 'in module PCI
0317 0210 LOCATE 17,7:COLOR 15,0:PRINT " ";
0339 0210 ACTIVE1 = 0
0344 0210 RETURN
0348 0210 T1B: 'load reagent profile
35 0349 0210 IF MENU(16,1) = "" THEN LOCATE 25,1:PRINT "Reagent Name is not specified";GOSUB ANYKEY:RETURN
0391 0210 GOSUB SEARCH
0397 0210 IF I1 < (REAGENT + 1) THEN GOTO FOUND
03A8 0214 LOCATE 25,10-LEN(MENU(16,1))/2:PRINT MENU(16,1); " not Found";
40 0404 0214 GOSUB ANYKEY: 'wait for a keyhit
040A 0214 RETURN
040E 0214 FOUND:
0413 0214 FILES = RIGHTS(STR$(I1),LEN(STR$(I1))-1) + ".REA.B37"
0437 0218 OPEN FILES FOR INPUT AS #1: 'set pattern data file for read
45 0448 0218 INPUT #1,MENU(0,0): 'read frequency
0448 0218 INPUT #1,MENU(1,0): 'read amplitude
048B 0218 INPUT #1,MENU(2,0): 'read stroke delay
04AE 0218 INPUT #1,MENU(3,0): 'read pulse width
04D1 0218 INPUT #1,MENU(4,0): 'read rise time
04F4 0218 INPUT #1,MENU(5,0): 'read fall time
50 0519 0218 INPUT #1,MENU(7,1): 'read concentration
0530 0218 INPUT #1,MENU(8,1): 'read density
0541 0218 INPUT #1,MENU(9,1): 'read viscosity
05B5 0218 INPUT #1,MENU(10,1): 'read surface tension
55 05A9 0218

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5 Reagent Jet Printer
Reagent Calibration

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IBM Personal Computer BASIC Compiler V2.00

Offset	Data	Source Line
05A9	0218	CLOSE #1: 'done with data file
10 05B0	0218	OPEN "SEADIR.RJP" FOR OUTPUT AS #1
05B0	0218	PRINT #1,FILES: 'save filenames in default file
05C2	0218	PRINT #1,REMS(6,1): 'save the directory name as well
05D2	0218	CLOSE #1
05F4	0218	GOSUB DISP.PARMS: 'show all parameters
05F8	0218	RETURN
15 0601	0218	TIC: 'save reagent profile
0605	0218	IF REMS(6,1) = "" THEN LOCATE 25,1:PRINT "Reagent Name is not specified";GOSUB ANYKEY:RETURN
060A	0218	OPEN "READIR.RJP" FOR INPUT AS #1
064E	0218	INPUT #1,REARUMI
065F	0218	CLOSE #1
20 0671	0218	IF REARUMI < 80 THEN GOTO SAVE.REA
0678	0218	LOCATE 25,1:PRINT "Directory is Full (80 reagents max.)"
0687	0218	GOSUB ANYKEY:RETURN
06A1	0218	SAVE.REA:
06AB	0218	GOSUB SEARCH
06B0	0218	IF IZ > REARUMI THEN GOTO SAVEREA1
25 06B6	0218	REARUMI = IZ
06C7	0218	COLOR 15,0
06CE	0218	LOCATE 25,1:PRINT REMS(6,1);" already exists. Replace it with new values? ";
06DA	0218	AS = ""
070C	0218	WHILE AS = ""
0716	0218	AS = INKEY\$
30 0725	0218	WEND
072F	0218	LOCATE 25,1:PRINT SPACES(79);
0732	0218	IF AS = "Y" OR AS = "y" THEN GOTO REPLACE
074F	0218	RETURN
0778	0218	
077C	0218	SAVEREA1:
35 077C	0218	KILL "READIR.OLD": 'delete old backup directory
0781	0218	NAME "READIR.RJP" AS "READIR.OLD": 'save old directory
0788	0218	OPEN "READIR.OLD" FOR INPUT AS #1
0792	0218	OPEN "READIR.RJP" FOR OUTPUT AS #2: 'set up new dir
07A3	0218	
40 07B5	0218	INPUT #1,REARUMI: 'read number of dir entries
07B5	0218	REARUMI = REARUMI + 1: 'increase by 1
07C7	0218	WRITE #2,REARUMI: 'save in new directory
07D9	0218	
07E1	0218	FOR I=1 TO REARUMI - 1
07E1	0218	LINE INPUT #1,AS: 'read entry from old dir
45 07FA	021C	PRINT #2,AS: 'write entry in new directory
0807	021C	NEXT I
0817	021C	
0832	0220	CLOSE #1
0832	0220	
0839	0220	PRINT #2,REMS(6,1): 'write new entry to new directory
50 0839	0220	CLOSE #2: 'done with directory
0842	0220	
0842	0220	REPLACE:
0847	0220	FILES = RIGHTS(STR\$(REARUMI),LEN(STR\$(REARUMI))-1) + "REA.RJP"
0888	0220	

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Reagent Jet Printer
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IBM Personal Computer BASIC Compiler V2.00

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Offset  Data  Source Line
10 0889 0220      OPEN FILE# FOR OUTPUT AS #1: 'create new pattern data file
0890 0220      WRITE #1, MENU(10,0): 'store frequency
0891 0220      WRITE #1, MENU(11,0): 'store amplitude
0892 0220      WRITE #1, MENU(12,0): 'store strobe delay
0893 0220      WRITE #1, MENU(13,0): 'store pulse width
0894 0220      WRITE #1, MENU(14,0): 'store rise time
0895 0220      WRITE #1, MENU(15,0): 'store fall time
15 0913 0220      WRITE #1, MENU(16,0): 'store concentration
0914 0220      WRITE #1, MENU(17,0): 'store density
0915 0220      WRITE #1, MENU(18,0): 'store viscosity
0916 0220      WRITE #1, MENU(19,0): 'store surface tension
20 0917 0220      CLOSE #1: 'done with data file
0918 0220      OPEN "READER.RJP" FOR OUTPUT AS #1
0919 0220      PRINT #1, FILE#: 'save filename in default file
0920 0220      PRINT #1, MENU(16,1): 'save the directory name as well
25 0921 0220      CLOSE #1
0922 0220      RETURN
0923 0220      SEARCH:
0924 0220      OPEN "READER.RJP" FOR INPUT AS #1
0925 0220      INPUT #1, REAMU(1): 'read number of patterns in dir
30 0926 0220      I1 = 1: 'set entry pointer
0927 0220      SLOOP:
0928 0220      LINE INPUT #1, A1: 'read next pattern name from dir
0929 0220      IF A1 = MENU(16,1) THEN GOTO SEARCH.DONE: 'compare name with dir entry
0930 0220      I1 = I1 + 1
0931 0220      IF I1 < (REAMU(1) + 1) THEN GOTO SLOOP: 'check for done
35 0932 0220      SEARCH.DONE:
0933 0220      CLOSE #1
0934 0220      RETURN
0935 0220      T10:
40 0936 0220      'return with no change to exit reagent calibrate
0937 0220      PRINT #3, "M";
0938 0220      CLOSE #3: 'close cca channel
0939 0220      RETURN
0940 0220      T2:
45 0941 0220      'process "+" key
0942 0220      IF MENU(1) > 5 THEN RETURN
0943 0220      NEWTIME = TIMER
0944 0220      DELTATIME = NEWTIME - OLDTIME
0945 0220      OLDTIME = NEWTIME
0946 0220      IF DELTATIME > 0.15 THEN MULTI = 1 ELSE MULTI = MULTI + 1
0947 0220      IF MULTI > 100 THEN MULTI = 100
50 0948 0220      MENU(MENU(1,0) + MENU(MENU(1,0) + MENU(MENU(1,3) + MULTI): 'add increment
0949 0220      IF MENU(MENU(1,0) > MENU(MENU(1,1) THEN MENU(MENU(1,0) = MENU(MENU(1,1): 'check max value
0950 0220      COLOR 15,1: GOSUB DISPMENU: RETURN: 'show new value
0951 0220      T3:
0952 0220      'process "-" key
0953 0220      IF MENU(1) > 5 THEN RETURN
0954 0220      NEWTIME = TIMER
55 0955 0220

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Reagent Jet Printer
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IBM Personal Computer BASIC Compiler V2.00

Offset	Data	Source Line
0C3B	022E	DELTA TIME = NEW TIME - OLD TIME
0C4B	022E	OLD TIME = NEW TIME
0C55	022E	IF DELTA TIME > 0.15 THEN MULTI = 1 ELSE MULTI = MULTI + 1
0C77	022E	IF MULTI > 100 THEN MULTI = 100
0C89	022E	MENU(MENU,0) = MENU(MENU,0) - MENU(MENU,3) * MULTI: 'sub increment
0C8B	022E	IF MENU(MENU,0) < MENU(MENU,2) THEN MENU(MENU,0) = MENU(MENU,2): 'check min value
0B32	022E	COLOR 15,1:GOSUB DISPKMENU:RETURN: 'show new value
0B49	022E	
0B49	022E	T4: 'process up arrow key
0B4E	022E	IF MENU MOD 6 = 0 THEN RETURN: 'in top row already
0B63	022E	DIFF1 = -1:GOSUB NEXTMENU:RETURN: 'move pointer up one
0B74	0230	
0B74	0230	T5: 'process down arrow key
0B79	0230	IF MENU MOD 6 = 5 THEN RETURN: 'in bottom row already
0B8F	0230	DIFF2 = 1:GOSUB NEXTMENU:RETURN: 'move pointer down one
0BA0	0230	
0BA0	0230	T6: 'process left arrow key
0BA5	0230	IF INT(MENU / 6) = 0 THEN RETURN: 'in left column already
0B85	0230	DIFF3 = -6:GOSUB NEXTMENU:RETURN: 'move pointer one left
0BD6	0230	
0BD6	0230	T7: 'process right arrow key
0BD8	0230	IF INT(MENU / 6) = 2 THEN RETURN: 'in right column already
0BFE	0230	DIFF4 = 6:GOSUB NEXTMENU:RETURN: 'move pointer one right
0E0F	0230	
0E0F	0230	T8: 'input keys into KEYBUFs until (cr) is entered
0E14	0230	IF MENU > 10 THEN RETURN
0E23	0230	LOCATE 25,30:COLOR 31,0:PRINT "ENTER NEW VALUE";:COLOR 15,0
0E35	0230	KEYBUFs = AS
0E3F	0234	WHILE AS <> CHR\$(13)
0E72	0234	LOCATE 25,47:PRINT SPACES(13);
0E8F	0234	LOCATE 25,47:PRINT KEYBUFs;
0EA9	0234	AS = ""
0EB3	0234	WHILE AS = ""
0EC2	0234	AS = INKEY\$
0EC2	0234	IF ACTIVE1 = 1 AND DOWNTIME < TIMER THEN GOSUB PEN.DOWN
0EF6	0234	WEND
0EF9	0234	IF AS = CHR\$(8) AND LEN(KEYBUFs) > 0 THEN KEYBUFs = LEFT\$(KEYBUFs,LEN(KEYBUFs)-1)
0F3B	0234	IF AS > CHR\$(31) AND LEN(KEYBUFs) < 15 THEN KEYBUFs = KEYBUFs + AS
0F75	0234	WEND
0F79	0234	
0F79	0234	IF MENU > 5 THEN GOTO STORESTRINGS
0F8B	0234	
0F8B	0234	TEMP = VAL(KEYBUFs) 'temp has value of keys input
0F9B	0238	
0F9B	0238	'round off temp according to step size in menu array
0F9B	0238	TEMP = INT(TEMP / (MENU(MENU,3) + .5)) * MENU(MENU,3)
0FD1	0238	
0FD1	0238	'test TEMP for maximum and minimum values in menu array
0FD1	0238	IF TEMP > MENU(MENU,1) THEN TEMP = MENU(MENU,1)
1010	0238	IF TEMP < MENU(MENU,2) THEN TEMP = MENU(MENU,2)
104F	0238	
104F	0238	'insert new value into menu array and update screen
104F	0238	MENU(MENU,0) = TEMP
106B	0238	LOCATE 25,30:PRINT SPACES(40);

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Offset	Date	Source Line
10	1098 0238	COLOR 0,7:GOSUB DISPMENU
	109A 0238	RETURN
	109E 0238	
	109E 0238	STRASTRING:
	10A3 0238	MENU\$(MENU,1) = KEYBUF
	10B7 0238	LOCATE 25,30:PRINT SPACES(40);
15	10BC 0238	COLOR 0,7:GOSUB DISPMENU
	10EE 0238	RETURN
	10F2 0238	
	10F2 0238	PEL.DON:
	10F7 0238	DOWTIME = TIMER + 1
	1107 0238	PRINT 83,"B");
20	1117 0238	RETURN
	1118 0238	
	1118 0238	ANYKEY:
	1120 0238	LOCATE 25,64:PRINT "Strike any key..";
	113A 0238	AS = ""
	1144 0238	WHILE AS = ""
25	1153 0238	AS = INKEY\$
	115D 0238	WEND
	1160 0238	LOCATE 25,1:COLOR 15,0:PRINT SPACES(79);:COLOR 15,1
	1196 0238	RETURN
	119A 0238	
	119A 0238	NEWMENU: 'write old item in yellow, point to and highlight new item
30	119F 0238	COLOR 14,0:GOSUB DISPMENU
	1191 0238	MENU = MENU + DIFF
	119D 0238	IF MENU = 11 THEN MENU = 10
	11CF 0238	IF MENU > 15 THEN MENU = 15
	11E1 0238	COLOR 0,7:GOSUB DISPMENU:RETURN
	11F7 0238	
35	11F7 0238	INITIALIZE:
	11FC 0238	'change to second screen and display messages
	11FC 0238	SCREEN 0,0,1,1:COLOR 7,0:CLS:LOCATE 10,28:PRINT "Initializing Menu Display";
	1240 0238	LOCATE 12,33:PRINT "Please Wait...."
	125A 0238	
	125A 0238	'initialize variables
40	125A 0238	
	125A 0238	ACTIVE = 0: 'not printing
	1261 0238	
	1261 0238	'initialize plotter cos channel
	1261 0238	
45	1261 0238	OPEN "COM1:2400,N,8,2" AS #3
	1273 0238	PRINT #3,";UECS,EFV1,H");
	1283 0238	
	1283 0238	'initialize digital port
	1283 0238	SCR1 = 4
	128A 0238	CALL DIGITAL.OUT(SCR1)
50	129A 0238	SCR1 = 0
	12A1 0238	CALL DIGITAL.OUT(SCR1); 'pulse reset line to set amplitude to 0V.
	12B1 0238	SCR1 = 4
	12B8 0238	CALL DIGITAL.OUT(SCR1)
	12C8 0238	
	12C8 0238	'set hardware pulse width
55	12C8 0238	CALL SET.BOT.WIDTH(5) 'in module PC1

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15% Personal Computer BASIC Compiler V2.00

Offset	Data	Source Line
70	12DE 023C	
	12DE 023C	'initialize beam arrays
	12DE 023C	RESTORE A00047A
	12E3 023C	FOR I=0 TO 17
	12E9 023C	READ MEMU(12,0),MEMU(12,1);
	131B 023C	READ MEMU(12,1),MEMU(12,2),MEMU(12,3),MEMU(12,4)
75	137C 023C	NEXT I
	138F 023C	
	138F 023C	'set default reagent values
	138F 023C	
	138F 023C	MEMU(0,0) = 2000; 'frequency
	13A8 023C	MEMU(1,0) = 0; 'amplitude
20	13C4 023C	MEMU(2,0) = 1; 'strobe delay
	13E0 023C	MEMU(3,0) = 0.90; 'pulse width
	13FC 023C	MEMU(4,0) = 470; 'rise time
	141B 023C	MEMU(5,0) = 0.70; 'fall time
	1436 023C	
	1436 023C	MEMU(6,0) = 0; 'noise
25	1452 023C	MEMU(7,0) = 0; 'concentration
	146E 023C	MEMU(8,0) = 0; 'density
	148A 023C	MEMU(9,0) = 0; 'viscosity
	14A6 023C	MEMU(10,0) = 0; 'surface tension
	14C2 023C	
	14C2 023C	OLD.AMP.VALUES = 0 'initial value of 0 volts
30	14C9 023C	
	14C9 023C	'change active displayed screen to first screen to draw and display parameters
	14C9 023C	
	14C9 023C	SCREEN 0,0,0,1:CLS
	14E6 023C	
	14E6 023C	COLOR 13:LOCATE 1,32:PRINT "REAGENT CALIBRATE";
35	1507 023C	COLOR 9
	150E 023C	FOR I=2 TO 79
	1518 023C	LOCATE 3,1:PRINT "D";LOCATE 5,1:PRINT "H";LOCATE 19,1:PRINT "P";
	153F 023C	NEXT I
	155A 023C	FOR I=4 TO 18
	1594 023C	LOCATE 1,1:PRINT "J";LOCATE 1,28:PRINT "I";LOCATE 1,49:PRINT "A";LOCATE 1,80:PRINT "3";
40	1608 023C	NEXT I
	1626 023C	RESTORE TABLE
	1629 023C	FOR I=1 TO 12
	1637 023C	READ RI,CI,NI:LOCATE RI,CI:PRINT CHR\$(NI);
	166A 0244	NEXT I
	1685 0244	
45	1685 0244	'print three headings and instructions
	1685 0244	COLOR 10,0
	1691 0244	LOCATE 4,7:PRINT "DROP PARAMETERS";
	16A9 0244	LOCATE 4,39:PRINT "REAGENT PARAMETERS"
	16C3 0244	LOCATE 4,71:PRINT "COMMANDS";
	16DF 0244	
50	16DF 0244	COLOR 7:LOCATE 21,20:PRINT "Use ";COLOR 15:PRINT CHR\$(27);CHR\$(32);CHR\$(26);
	1729 0244	PRINT CHR\$(37);CHR\$(24);CHR\$(32);CHR\$(25);COLOR 7:PRINT " to position highlighted cursor";
	1768 0244	LOCATE 22,18:PRINT "Use ";COLOR 15:PRINT "+";COLOR 7:PRINT " or ";COLOR 15:PRINT "-";
	178E 0244	COLOR 7:PRINT " to scroll current value up or down";
	1792 0244	LOCATE 23,26:PRINT "Use ";COLOR 15:PRINT "DT";COLOR 7:PRINT " to activate selection";
55	1814 0244	

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IBM Personal Computer BASIC Compiler V2.00

Offset	Data	Source Line
25		
1814	0244	DISP.PARMS:
1819	0244	'display 18 menu choices in yellow
1819	0244	
1819	0244	COLOR 14,0
1825	0244	FOR MENU1 = 0 TO 17
30 1829	0244	GOSUB DISPMENU
1831	0244	NEXT MENU1
1841	0244	
1841	0244	'set for reagent name and highlight it
1841	0244	MENU1 = 6:COLOR 0,7
1854	0244	GOSUB DISPMENU
35 185A	0244	
185A	0244	SCREEN 0,0,0,0
186F	0244	RETURN
1873	0244	REM SPACE

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10 Offset  Date   Source Line
      1873 0244 DISPENS:
      1878 0244 LOCATE (MENU MOD 6)+2+7,(INT(MENU/6)+28+2)+(5+INT(MENU/12))
      1884 0244 PRINT MENU(MENU,0)
      1887 0244 IF MENU > 5 THEN GOTO SHOWSTRING: ' no value to display
15      1901 0244 LOCATE (MENU MOD 6)+2+7,MENU(MENU,4)
      1903 0244 PRINT USING MENU(MENU,1);MENU(MENU,0);
      1906 0244 IF MENU > 2 THEN RETURN
      1907 0244 ON MENU+1 GOSUB SET.FREQ, SET.AMP, SET.DELAY
      1908 0244 RETURN
      198A 0244 SHOWSTRING:
20      198F 0244 IF MENU > 10 THEN RETURN
      199E 0244 LOCATE (MENU MOD 6)+2+7,48
      198A 0244 PRINT "
      19C7 0244 LOCATE (MENU MOD 6)+2+7,48
      19E3 0244 PRINT MENU(MENU,1)
25      1A02 0244 RETURN
      1A06 0244
      1A06 0244 SET.FREQ:
      1A0B 0244 TEMP = MENU(0,0)
      1A24 0244 CALL SET.DUT.RATE(TEMP); 'in module PCI
      1A34 0244 LED1 = 3-INT((TEMP+500)/1000)
30      1A57 0244 IF LED1 < 0 THEN LED1 = 0
      1A69 0244 SCRI = 4 + (LED1 * 32); 'set LED intensity
      1A89 0244 CALL DIGITAL.OUT(SCRI); 'in module PCI
      1A99 0244 RETURN
      1A9D 0244
      1A9D 0244 SET.AMP:
35      1AA2 0244 SCRI = CINT(MENU(MENU,0) * 255 / 150); 'convert volts to binary number
      1ACB 0244 IF SCRI = OLD.AMP.VALUE THEN RETURN
      1ADC 0244 TEMP1 = SCRI - OLD.AMP.VALUE; 'calculate delta
      1AEB 0244 OLD.AMP.VALUE = SCRI; 'update old value to current value
      1AEF 0244 DIG.VAL1 = 6
      1AF6 0244 IF TEMP1 < 0 THEN DIG.VAL1 = 5
40      1B0B 0244 TEMP1 = ABS(TEMP1)
      1B15 0244 FOR I1 = 1 TO TEMP1
      1B22 0244 SCRI = DIG.VAL1 + (32+LED1)
      1B3F 0244 CALL DIGITAL.OUT(SCRI); 'pulse higher or lower
      1B4F 0244 SCRI = 4 + (32 + LED1)
      1B6F 0244 CALL DIGITAL.OUT(SCRI); 'set port to normal
45      1B7F 0244 NEXT I1
      1B91 0244 RETURN
      1B95 0244
      1B95 0244 SET.DELAY:
      1B9A 0244 TEMP = MENU(2,0)
      1B96 0244 CALL SET.STROBE.DELAY(TEMP); 'in module PCI
50      1B04 0244 RETURN
      1B0A 0244
      1B0A 0244 REM SPACE

```

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Test Jet Printer
Agent Calibration

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12:24:57

IBM Personal Computer BASIC Compiler V2.00

```
Offset Data Source Line
18CA 024C ***** DATA USED BY THIS MODULE *****
18CA 024C
75 18CA 024C ARRDATA:
18CF 024C DATA "Frequency" Hz,"10,000",10000,1,1,16
18D1 024C DATA "Amplitude" V,"100",150,0,1,19
18D3 024C DATA "Strobe Delay" us,"10,000.0",15999.5,.5,.5,16
18D5 024C DATA "Pulse Width" ,"100",999,0,1,19
18D7 024C DATA "Rise Time" ,"100",999,0,1,19
20 18D9 024C DATA "Fall Time" ,"100",999,0,1,19
18DB 024C DATA "Mass","",0,0,0,0
18DD 024C DATA "Concentration","",0,0,0,0
18DF 024C DATA "Density","",0,0,0,0
18E1 024C DATA "Viscosity","",0,0,0,0
18E3 024C DATA "Surface Tension","",0,0,0,0
25 18E5 024C DATA "",0,0,0,0
18E7 024C DATA "START","",0,0,0,0
18E9 024C DATA "LOAD","",0,0,0,0
18EB 024C DATA "SAVE","",0,0,0,0
18ED 024C DATA "EXIT","",0,0,0,0
18EF 024C DATA "",0,0,0,0
30 18F1 024C DATA "",0,0,0,0
18F3 024C
18F3 024C TABLE:
18F8 024C DATA 3,1,218
18FA 024C DATA 3,28,210
18FC 024C DATA 3,69,210
35 18FE 024C DATA 3,80,191
1C00 024C DATA 5,1,198
1C02 024C DATA 5,28,206
1C04 024C DATA 5,69,206
1C06 024C DATA 5,80,191
1C08 024C DATA 19,1,192
40 1C0A 024C DATA 19,28,208
1C0C 024C DATA 19,69,208
1C0E 024C DATA 19,80,217
1C10 024C
1C10 024C END SUB
1C17 024C
45 1C17 024C
23EB- 024C
```

50426 Bytes Available
43960 Bytes Free

50 0 Warning Error(s)
0 Severe Error(s)

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Reagent Jet Printer Pattern Entry/Modification

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10:46:13

Offset Data Source Line IBM Personal Computer BASIC Compiler V2.00

```

5      0030 0006 REM $TITLE: 'Reagent Jet Printer' $SUBTITLE: 'Pattern Entry/Modif
      0030 0006 ication'
      0030 0006 'MODULE - 'PATENT' Pattern creation, modification, and filing
      0030 0006 '
10     0030 0006 'AUTHOR - M. A. Enevold
      0030 0006 '
      0030 0006 'COPYRIGHT (C) 1985 ABBOTT LABORATORIES
      0030 0006 '
15     0030 0006 'REVISION - 1.2 03-10-86 WAE Remove Mouse inputs
      0030 0006 '
      0030 0006 '      1.1 02-20-86 WAE Add 80 pattern limit to save
      0030 0006 '      1.0 01-13-86 WAE Creation of initial code
      0030 0006 '
      0030 0006 'SYSTEM - This code can only be compiled by the BASCOM
      0030 0006 '      COMPILER, it will not run under the INTERPRETER!!
20     0030 0006 '
      0030 0006 'DESCRIPTION:
      0030 0006 '      This module allows the user to LOAD, SAVE, DIRectory, D
      0030 0006 RAW and
25     0030 0006 '      enter repeat count and other parameters for a pattern t
      0030 0006 o be printed.
      0030 0006 '      The low-resolution graphics mode is selected and a menu
      0030 0006 is displayed
      0030 0006 '      across the bottom of the screen. Using arrow keys
30     0030 0006 '      point to the action to be taken and then invoke that ac
      0030 0006 tion with the
      0030 0006 '      Enter key. In the DRAW mode, another menu is
      0030 0006 displayed which allows the user to select from LINE, RE
      0030 0006 CTangle,
35     0030 0006 '      Solid RECTangle, or CIRCLE pattern elements.
      0030 0006 '
      0030 0006 'DATA DICTIONARY
      0030 0006 '      SCHOATL(50,5) 51 Row (Elements) by 6 Coluan array f
      0030 0006 or storing pattern elements
40     0030 0006 '      CURSORI(9) Storage for cursor graphics icon
      0030 0006 '      MENUS(6) Up to 7 menu names can be saved here
      0030 0006 '      ELNUMX Count of number of elements in a patt
      0030 0006 ern
      0030 0006 '      XI YI Current location of graphics cursor
45     0030 0006 '      GRID Value of one dot space on the screen
      0030 0006 (default is 0.003")
      0030 0006 '      ROWI COLI Location to print instructions
      0030 0006 '      AS Storage for single key-strokes or inp
      0030 0006 ut strings
50     0030 0006 '      MENUMX Which menu is being displayed (1 or 2
      0030 0006 )
      0030 0006 '      ITEM Pointer to which menu item is highlig
      0030 0006 hted (0 - 6)
      0030 0006 '      REPEATX Number of times pattern is to be repe
      0030 0006 ated when printed
55     0030 0006 '      IDFF YOFF X and Y axis distance between the pri
      0030 0006 nting of repeated patterns
      0030 0006 '      ROWSP COLSP Row and Coluan spacing for printing a
      0030 0006 ultiple sets of patterns

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Reagent Jet Printer
Pattern Entry/Modification

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IBM Personal Computer BASIC Compiler V2.00

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Offset	Data	Source Line	
0030	0006	• PATXUMZ	Number of patterns stored in the pattern directory PATDIR.RJP
0030	0006	• DROWZ DCOLZ	Row and Column location to display directory entries
0030	0006	• NAMES	Pattern name to be LOAded or SAVEd to directory
25	0030	0006	• IZ JZ Counters used to LOAD or SAVE the element data from/to pattern data file
0030	0006	• FILES	Name of pattern data file
0030	0006	• TEMPI	Which type of element is being drawn.
30	0030	0006	• 1 = Line 2 = Rectangle 3 = Solid Rectangle 4 = Circle
0030	0006	• FLASZ	Same as TEMPI above
0030	0006	• STARTMSG: ENDMSG:	Message display for startpoint and endpoint of element entry
35	0030	0006	• IIZ YIZ Starting cursor position for element being drawn
0030	0006	• DIZ DYI	Delta X and Y values used to re-position cursor after arrow key
40	0030	0006	• MAXITEM The highest number item in the current menu display
0030	0006	• IS IE	Starting and ending X position of the menu highlighting blue box
0030	0006	• RADIUSZ	The calculated radius of a circle to be displayed
45	0030	0006	REM \$PAGE

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Reagent Jet Printer
Pattern Entry/Modification

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70      Offset Data      Source Line      IBM Personal Computer BASIC Compiler V2.00

        0030 0006      SUB PATENTRY STATIC
        0047 0006
        0047 0006      WIDTH 40:SCREEN 1:CLS
15      005F 0006      DIM SCADAT$(50,5),CURSOR$(9),MENU$(6)
        0060 029A      ELNUNX = 0:IX=0:YI=0:GRID = 0.005
        007F 02A4
        007F 02A4      LINE (0,0)-(6,6),,B
        00A1 02A4      LINE (0,3)-(6,3),,B
20      00C5 02A4      LINE (3,0)-(3,6),,B
        00E9 02A4      PRESET (3,3)
        00F5 02A4      GET (0,0)-(6,6),CURSOR$
        0116 02A4      CLS
        011D 02A4
25      011D 02A4      LINE (0,0)-(319,190),,B
        0140 02A4
        0140 02A4      RESTORE INSTRU
        0147 02A4      FOR I=1 TO 4
        0151 02A4          READ ROW$,COL$,A$
30      0164 02AC          LOCATE ROW$,COL$:PRINT A$;
        0180 02AC      NEXT I
        019B 02B0
        019B 02B0      FIRST:
        01A0 02B0          MENUNUM = 1
35      01AA 02B4          GOSUB SUBMENU
        01B0 02B4
        01B0 02B4      ON ITEM + 1 GOTO PATDIR, PATLOAD, PATSAVE, PATDRAW, REP
        EAT, PATENT
        01CD 02BB      GOTO FIRST
40      01D0 02BB
        01D0 02BB      REPEAT:
        01D5 02BB          GOSUB ITEMBOXERASE: 'erase blue box around DIR
        01DB 02BB          LOCATE 25,1:PRINT SPACES(39); 'erase menu line
        01FB 02BB          LOCATE 25,1:INPUT;"Enter Repeat Count ",REPEAT$
45      021B 02BA          LOCATE 25,1:PRINT SPACES(39); 'erase menu line
        0235 02BA          LOCATE 25,1:INPUT;"Enter X Axis Offset ",IOFF
        0255 02BE          LOCATE 25,1:PRINT SPACES(39); 'erase menu line
        0272 02BE          LOCATE 25,1:INPUT;"Enter Y Axis Offset ",YOFF
        0292 02C2          GOTO FIRST
50      0296 02C2      PATENT:
        029B 02C2          WIDTH 80:SCREEN 0:CLS
        02B2 02C2          EXIT SUB
        02B6 02C2      REM $PAGE

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Reagent Jet Printer                                     PAGE 4
Pattern Entry/Modification                             07-05-86
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Offset Data Source Line IBM Personal Computer BASIC Compiler V2.00

0286 02C2 PATDIR: 'list directory of patterns
028B 02C2 GOSUB ITERERASE: 'erase blue box around DIR
02C1 02C2 LOCATE 25,1:PRINT SPACES(39); 'erase menu line
02DE 02C2 OPEN "PATDIR.RJP" FOR INPUT AS #1: 'open directory
                                file
02EF 02C2 INPUT #1, PATNUM1: 'read number of patterns in dir
                                ectory
0301 02C4 LINE (1,1)-(318,189),0,BF: 'erase graphics tablet
0326 02C4 I = 0: 'set counter
0330 02C4
0330 02C4 DISLOOP:
0335 02C4 I = I + 1: 'set for next value
0344 02C4 IF I > PATNUM1 THEN GOTO DIREXIT: 'test for done
035B 02C4 IF INT((I-1)/44) <> (I-1)/44 THEN GOTO SHOWNEXT
0364 02C4 IF INT((I-1)/44) < 1 THEN GOTO SHOWNEXT
03A9 02C4
03A9 02C4 LOCATE 25,1:PRINT "More to Display. Continue ? (Y or N)
                                *;
03C3 02C4 GOSUB CORLOOP: 'wait for Y or N response
03C9 02C4 IF AS = "N" THEN GOTO DIREXIT: 'if N then don't contin
                                ue
03DC 02C4
03DC 02C4 LINE (1,1)-(318,189),0,BF: 'erase graphics tablet
0401 02C4
0401 02C4 SHOWNEXT:
0406 02C4 DROWZ = ((I - 1) MOD 22) + 2: 'calculate row for disp
                                lay
0422 02C6 DCOLZ = 4: 'set column to 4
0429 02C6 IF ((I - 1) MOD 44) > 21 THEN DCOLZ = 23: 'reset column
                                if necessary
044C 02C8
044C 02C8 LINE INPUT #1, AS: 'read next name from directory
0459 02C8 LOCATE DROWZ,DCOLZ:PRINT AS; 'PRINT NAME
0475 02C8 GOTO DISLOOP
0479 02C8
0479 02C8 DIREXIT:
047E 02C8 CLOSE #1: 'terminate access to PATDIR.RJP
0485 02C8 GOTO FIRST
0489 02C8
0489 02C8 REM $PAGE

```

Reagent Jet Printer
Pattern Entry/Modification

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IBM Personal Computer BASIC Compiler V2.00

```

5      0489 02C2  PATLOAD:
      048E 02C3      GOSUB ITEM201ERASE: 'erase blue box around DIR
      0494 02C3      OPEN "PATDIR.RJP" FOR INPUT AS #1
      04A5 02C3      INPUT #1,PATNUM1: 'read number of patterns in dir
10     04B7 02C3      GOSUB GETNAME: 'prompt for and input pattern n
      04B8 02C3      ARE
      04B9 02C3      LINE (1,1)-(318,189),0,BF: 'erase graphics tablet
      04E2 02C3
      04E2 02C3      GOSUB SEARCH
15     04E8 02C3
      04E8 02C3      IF IZ < (PATNUM1 + 1) THEN GOTO FOUND
      04FC 02CA      LOCATE 10,16-(LEN(NAME$)/2):PRINT NAME$;" not Found";
      0531 02CE      LOCATE 12,14:PRINT "Strike Any Key"
      0548 02CE      GOSUB ANYKEY: 'wait for a keyhit
20     0551 02CE      GOTO FIRST
      0553 02CE
      0555 02CE      FOUND:
      055A 02CE      FILE$ = RIGHT$(STR$(IZ),LEN(STR$(IZ))-1) + "PAT.RJP"
      057E 02D2      OPEN FILE$ FOR INPUT AS #1: 'set pattern data file
25     058F 02D2      for read
      058F 02D2      INPUT #1,ELNUM1: 'read number of elements in pat
      05A1 02D2      tern
      05A1 02D2      INPUT #1,GRID: 'read grid size
      05B3 02D2      INPUT #1,REPEAT1: 'read repeat count
30     05C5 02D2      INPUT #1,XOFF: 'read x axis offset for repeat
      05D7 02D2      INPUT #1,YOFF: 'read y axis offset for repeat
      05E9 02D2
      05E9 02D2      FOR IZ = 0 TO ELNUM1 - 1
      05F7 02D4      FOR JZ = 0 TO 5
35     05FD 02D4      INPUT #1,SEARCH$(IZ,JZ):'read file into screen
      0621 02D6      array
      0631 02D6      NEXT JZ
      0643 02D6      CLOSE #1: 'done with data file
40     064A 02D6
      064A 02D6      OPEN "PATDEF.RJP" FOR OUTPUT AS #1
      065C 02D6      PRINT #1,FILE$: 'save filename in default file
      066C 02D6      PRINT #1,NAME$: 'save the directory name as well
45     067C 02D6      CLOSE #1
      0683 02D6
      0683 02D6      GOTO REDRAW
      0687 02D6
50     0687 02D6      SEARCH:
      068C 02D6      IZ = 1: 'set entry pointer
      0693 02D6      SLOOP:
      0698 02D6      LINE INPUT #1,AS: 'read next pattern name from dir
      06A5 02D6      IF AS = NAME$ THEN GOTO SEARCH.END: 'compare name with dir entry
55     06B8 02D6      IZ = IZ + 1
      06C1 02D6      IF IZ < (PATNUM1 + 1) THEN GOTO SLOOP: 'check for done
      06D4 02D6      SEARCH.END:

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Reagent Jet Printer
Pattern Entry/Modification

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Offset Data Source Line

IBM Personal Computer BASIC Compiler V2.00

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06D9 02D6 CLOSE #1: 'not found so close file and display me
ssage

06E0 02D6 RETURN

06E4 02D6

06E4 02D6 REM SPAGE

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Keagent Jet Printer
Pattern Entry/Modification

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Offset Data Source Line IBM Personal Computer BASIC Compiler V2.00

```
5      06E4 02D6 PATSAVE:
      06E9 02D6      GOSUB ITEMSOIERASE: 'erase blue box around DIR
      06EF 02D6      IF ELNUM1 = 0 THEN GOTO FIRST: 'no elements in pattern
      06FE 02D6      OPEN "PATDIR.RJP" FOR INPUT AS #1
10     070F 02D6      INPUT #1,PATNUM1
      0721 02D6      IF PATNUM1 < 80 THEN GOTO SAVE.PAT: 'directory full
                                at 80 patterns
      0730 02D6      CLOSE #1
      0737 02D6      LOCATE 25,1:PRINT SPACE$(39);; 'erase bottom line
15     0754 02D6      LOCATE 25,1:PRINT "Directory is full (80 patterns max)"
                                ;
      076E 02D6      GOSUB ANYKEY:GOTO FIRST
      0778 02D6      SAVE.PAT:
20     077D 02D6      GOSUB GETNAME: 'prompt for and get pattern name
      0783 02D6      GOSUB SEARCH
      0789 02D6      IF IZ > PATNUM1 THEN GOTO ADD.NEW.PATTERN
      079A 02D6      LINE (1,1)-(318,189),0,BF: 'erase graphics tablet
      07BF 02D6      LOCATE 10,13-(LEN(NAME$)/2):PRINT NAME$;" already exist
25     S.*;
      07F4 02D6      LOCATE 12,15:PRINT "Replace it?"
      080E 02D6      PATNUM1 = IZ
      0815 02D6      AS = ""
      081F 02D6      WHILE AS = ""
30     082E 02D6          AS = INKEY$
      0838 02D6      WEND
      083B 02D6      IF AS = "Y" OR AS = "y" THEN GOTO SAVE.PATTERN
      0864 02D6      GOTO FIRST
      0868 02D6
35     0868 02D6      ADD.NEW.PATTERN:
      086D 02D6      KILL "PATDIR.OLD": 'delete old backup directory
      0874 02D6      NAME "PATDIR.RJP" AS "PATDIR.OLD": 'save old directory
                                tory
40     087E 02D6      OPEN "PATDIR.OLD" FOR INPUT AS #1
      088F 02D6      OPEN "PATDIR.RJP" FOR OUTPUT AS #2: 'set up new dir
      08A1 02D6      INPUT #1,PATNUM1: 'read number of dir entries
      08B3 02D6      PATNUM1 = PATNUM1 + 1: 'increase by 1
      08BC 02D6      WRITE #2,PATNUM1: 'save in new directory
      08CD 02D6      FOR I=1 TO PATNUM1 - 1
45     08E6 02DA          LINE INPUT #1,AS: 'read entry from old dir
      08F3 02DA          PRINT #2,AS: 'write entry in new directory
      0903 02DA      NEXT I
      091E 02DA      PRINT #2,NAME$: 'write new entry to new directory
50     TY
      092E 02DA      CLOSE #1:CLOSE #2: 'done with directory
      093C 02DA      SAVE.PATTERN:
      0941 02DA      FILES = RIGHTS(STR$(PATNUM1),LEN(STR$(PATNUM1))-1) + ".P
                                AT.RJP"
      0965 02DA      OPEN FILES FOR OUTPUT AS #1: 'create new pattern data file
55     a file
      0977 02DA      WRITE #1,ELNUM1: 'store number of elements
      0988 02DA      WRITE #1,GRID: 'store grid dimension
      0998 02DA      WRITE #1,REPEAT$: 'store repeat count
      09A9 02DA      WRITE #1,XOFF: 'store x axis offset for repeat
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Reagent Jet Printer                                     PAGE 8
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Offset  Data   Source Line      IBM Personal Computer BASIC Compiler V2.00

0989  02DA      WRITE #1,YOFF:      'store y axis offset for repeat
09C9  02DA      FOR IZ = 0 TO ELNMT - 1
09D7  02DC      FOR JI = 0 TO 5
09DD  02DC      WRITE #1,SCNDATZ(IZ,JZ):  'write screen a
                                rray to file
0A09  02DC      NEXT JI
0A10  02DC      NEXT IZ
0A22  02DC      CLOSE #1:      'done with data file
0A29  02DC      OPEN "PATDEF.RJP" FOR OUTPUT AS #1
0A3B  02DC      PRINT #1,FILES:      'save filename in defau
                                lt file
0A4B  02DC      PRINT #1,NAME$:      'save the directory nam
                                e as well
0A5B  02DC      CLOSE #1
0A62  02DC      GOTO FIRST
0A66  02DC      REM SPAGE

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5      0A60 02DC PATERM:
      0A63 02DC      GOSUB ITEMSC7EFHSE
      0A71 02DC      LINE (1,1)-(318,189),0,BF:      "Erase graphics tablet
10     0A96 02DC
      0A96 02DC NEXTEL:
      0A9E 02DC      MENUNUM = 2
      0AA5 02DC      GOSUB SUBMENU
      0AAB 02DC
      0AAB 02DC      ON ITEM + 1 GOTO ALINE, RECT, SRECT, ACIRCLE, REDRAW, B
15     0ACB 02DC      ACROP
      0ACB 02DC      GOTO NEXTEL
      0ACB 02DC BACKUP:
      0AD0 02DC      GOSUB ITEMBOIERASE
20     0AD6 02DC      GOTO FIRST
      0ADA 02DC
      0ADA 02DC ALINE:
      0ADF 02DC      TEMP1 = 1
      0AE6 02DE      STARTMS6 = "STARTING ENDPOINT"
25     0AF0 02E2      ENDMS6 = "ENDING ENDPOINT "
      0AFA 02E6      GOTO ENTERELEMENT
      0AFE 02E6
      0AFE 02E6 RECT:
      0B03 02E6      TEMP1 = 2
30     0B04 02E6      GOTO RECTMS6
      0B0E 02E6
      0B0E 02E6 SRECT:
      0B13 02E6      TEMP1 = 3
      0B1A 02E6 RECTMS6:
35     0B1F 02E6      STARTMS6 = "STARTING CORNER"
      0B29 02E6      ENDMS6 = "ENDING CORNER "
      0B33 02E6      GOTO ENTERELEMENT
      0B37 02E6
      0B37 02E6 ACIRCLE:
40     0B3C 02E6      TEMP1 = 4
      0B43 02E6      STARTMS6 = "CENTER OF CIRCLE"
      0B4D 02E6      ENDMS6 = "POINT ON CIRCLE "
      0B57 02E6
      0B57 02E6 ENTERELEMENT:
45     0B5C 02E6      GOSUB ITEMBOIERASE
      0B62 02E6      FLAG1=0
      0B69 02EB      LOCATE 25,1:PRINT SPACE$(39);
      0B86 02EB      LOCATE 25,1:PRINT STARTMS6;
      0BA0 02EB      GOSUB DISPCURSOR
50     0BA6 02EB FINDSTART:
      0BAB 02EB      GOSUB MOUSEACT
      0BB1 02EB      IF A$ = CHR$(27) THEN GOTO ABORT
      0BC8 02EB      IF A$ = CHR$(13) THEN GOTO SETSTART
      0BCF 02EB      GOSUB CURSORMOVE
      0BE5 02EB      GOTO FINDSTART
55     0BEE 02EB ABORT:
      0BED 02EB      GOSUB PLACECURSOR
      0BF3 02EB      GOTO NEXTEL
      0BF7 02EB

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Reagent Jet Printer
Pattern Entry/Modification

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Offset Data Source Line IEM Personal Computer BASIC Compiler V2.00

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0BF7 02EB SETSTART:
0BFC 02EB LOCATE 15,1:PRINT ENDS6:
0C16 02EB FLAG1 = TEMP1:Y11 = Y1:Y11 = Y1
0C28 02EC IF FLAG1 = 4 THEN PSET (Y1+4,Y1+4)
0C35 02EC FINDEND:
0C5A 02EC GOSUB MOUSEACT
0C60 02EC IF A$ = CHR$(27) THEN GOTO CANCELEL
0C77 02EC IF A$ = CHR$(13) THEN GOTO SAVEEL
0C8E 02EC GOSUB CURSORMOVE
0C94 02EC GOTO FINDEND
0C97 02EC CANCELEL:
0C9C 02EC GOSUB PLACECURSOR
0CA2 02EC ON FLAG1 GOSUB ER1, ER2, ER3, ER4
0CB3 02EC FLAG1 = 0
0CBA 02EC GOTO NEXTEL
0CBE 02EC SAVEEL:
0CC3 02EC GOSUB PLACECURSOR
0CC9 02EC IF FLAG1 = 4 THEN CIRCLE (Y1+4,Y1+4),SQR((Y1-Y11)^2+
(Y1-Y11)^2),,,,1
0D32 02EC GOSUB CORRECT
0D38 02EC IF A$="M" THEN GOTO REDRAW
0D4B 02EC STOREEL:
0D50 02EC SCNDAT1(ELNUM1,0) = FLAG1
0D6A 02EC SCNDAT1(ELNUM1,1) = Y11
0D85 02EC SCNDAT1(ELNUM1,2) = Y12
0DA0 02EC SCNDAT1(ELNUM1,3) = Y1
0DBB 02EC SCNDAT1(ELNUM1,4) = Y1
0DD6 02EC SCNDAT1(ELNUM1,5) = 0
0DEF 02EC ELNUM1 = ELNUM1 + 1
0DFB 02EC FLAG1 = 0
0DFF 02EC GOTO NEXTEL
0E03 02EC REM $PAGE

```

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Reagent Jet Printer
Pattern Entry/Modification

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Offset  Data  Source Line  IBM Personal Computer BASIC Compiler V2.00

      0E03 02EC REDRAW:
      0E08 02EC      GOSUB ITEMBOXERASE
      0E0E 02EC      LINE(1,1)-(318,189),0,BF
      0E33 02EC      IF ELNUM% = 0 THEN GOTO NEXTEL
10     0E42 02EC
      0E42 02EC      FOR J=0 TO ELNUM%-1
      0E58 02F0          ON SCNDATX(1,0) GOSUB RD1, RD2, RD3, RD4
      0E81 02F0      NEXT J
      0E9C 02F0      GOTO NEXTEL
15     0EA0 02F0
      0EA0 02F0      ***** Sub-routines called by main module *****
      0EA0 02F0
      0EA0 02F0      SUBMENU:
      0EA5 02F0
      0EA5 02F0          LOCATE 25,1:PRINT SPACES(39);
20     0EC2 02F0          ON MENUNUM GOSUB MENU1, MENU2
      0ED1 02F0
      0ED1 02F0          FOR I=0 TO 6
      0EDB 02F0              READ MENU$(I)
25     0EF2 02F0              LOCATE 25,(I*6)+2:PRINT MENU$(I);
      0F2B 02F0          NEXT I
      0F46 02F0
      0F46 02F0          READ MAXITEM
      0F4D 02F4          ITEM = 0
30     0F57 02F4
      0F57 02F4      NEWITEM:
      0F5C 02F4          GOSUB NEWITEMBOX
      0F62 02F4
      0F62 02F4      NEXTITEM:
35     0F67 02F4          GOSUB ITEMSEARCH
      0F6D 02F4          IF AS = CHR$(13) THEN RETURN:  ITEM has correct value
      0FB4 02F4          IF LEN(AS) < 2 THEN BEEP:GOTO NEXTITEM
      0F9A 02F4          IF ASC(MID$(AS,2,1)) = 75 THEN GOTO LEFTAR
      0FB6 02F4          IF ASC(MID$(AS,2,1)) = 77 THEN GOTO RIGHTAR
40     0FD2 02F4          BEEP:GOTO NEXTITEM
      0FD9 02F4
      0FD9 02F4      LEFTAR:
      0FDE 02F4          IF ITEM = 0 THEN GOTO NEXTITEM
      0FEE 02F4          GOSUB ITEMBOXERASE
45     0FF4 02F4          ITEM = ITEM - 1
      1003 02F4          GOTO NEWITEM
      1007 02F4
      1007 02F4      RIGHTAR:
      100C 02F4          IF ITEM = MAXITEM THEN GOTO NEXTITEM
50     101F 02F4          GOSUB ITEMBOXERASE
      1025 02F4          ITEM = ITEM + 1
      1034 02F4          GOTO NEWITEM
      1038 02F4
      1038 02F4      MENU1:
55     103D 02F4          RESTORE MX1
      1044 02F4          RETURN
      1048 02F4
      1048 02F4      MENU2:
      104D 02F4          RESTORE MX2

```